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only to instruct but to interest and lead the youthful mind to think and enquire, to compare and investigate; in a word, to qualify the learner for the contemplation and discovery of truth, and to imbue his mind with the points of real and useful knowledge—the leading principles and great axiomatic truths of science and philosophy. And indeed, the plan here adopted by Mr. Williams is calculated to collect and concentrate into a focus that knowledge and information which, in the ordinary method of treating scientific subjects, is spread and scattered over a wide and expansive surface;—or to employ an emphatic and a familiar expression, 'it condenses into a nutshell, that which is diffused through a mass of countless and cumbersome volumes, affording the maximum of information in the minimum of space, and while plain to the mind, it may be observed, is not altogether novel or of recent invention; the 'Compendium Physico Aristolico Cartesianæ,' of Sincerus—a work of considerable merit for the age, and from which subsequent compilers have borrowed much without acknowledgement—was published at Amsterdam about the end of the sixteenth century of the Christian era. Some thirty years ago, the author of the present work, it would seem, introduced the plan—as well of arrangement of matter as that of the form of its indoctrination—into one of his educational volumes; since the appearance of the latter, however, 'a host of similar books have been published, in which his matter,'—our author alleges—'has been so artistically diluted, and arranged in a form and finery so fantastic, that it is with some difficulty the descent of the bantlings can be traced to their progenitor.'

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Pyronomics (from the two Greek words πυρ, fire, and νομος, law, that is, the law of fire) is the science which explains and elucidates the nature, properties, causes, and effects of fire and heat, and their modifications.

What is the cause of natural heat?—Its nature and origin are as inexplicable as those of light and of all the phenomena of temperature.

Why is it supposed that terrestrial and solar heat vary in their nature and properties?—Because the solar rays pass through glass without heating it, but terrestrial rays are arrested by the glass, and the glass is consequently heated.

How is artificial heat produced?—By combustion, friction, striking flint, iron, and a few other hard substances together, and by spontaneous combustion.

Why is heat produced by combustion? — Because the oxygen gas of the atmosphere being decomposed by the process, the oxygen combines with the combustible body, and the caloric

which was held in a state of gaseous substance both in the atmospheric oxygen gas and the combustible body, being disengaged, is thrown off in the form of sensible heat in every direction.

How is it proved that oxygen occasions the combustion of a combustible body?—BECAUSE if a substance is burned in a sufficient quantity of oxygen gas, in a close vessel, and the product weighed, it will be found to have increased in weight exactly in proportion to the weight of the oxygen gas consumed, and the combustible body will have become incombustible.

How is perfect or complete combustion produced?—BY the presence of a sufficient quantity of pure air to afford the requisite quantity of oxygen, and a degree of heat sufficiently high and steady to effect the perfect union of all the inflammable particles with that oxygen.

How is this proved?—IF we examine a fire, we see no smoke in the fire itself, because the temperature there is sufficiently elevated; but at the point of the flame, where the yet unconsumed carbonaceous matter has come in contact with the cold atmospheric air, the smoke makes its appearance, because the temperature is then reduced below the point at which perfect combustion takes place; and the consequence is, that there is a deposition of carbon, and the heating power of the fire is just so much lower than it ought to be, by the number of degrees of heat which the smoke would have yielded had it been perfectly consumed.

How is the evolution or disengagement of light and heat produced?—IT results from the energy of the intense chemical affinity of the combustible body and the supporter of combustion, oxygen.

WHY does a fire give out warmth?—BECAUSE the heat is radiated.

WHAT are the uses and effects of heat?—IT is one of the most important agents in nature—the grand promoter of life and vegetation—one of the principal agents of the preservation of the world, by virtue of its repellent or counteractive power in opposition to that of attraction or gravitation. By its power, rocks, islands, hills, and mountains have been raised out of the innermost depths of the earth, and on its agency the preservation of the world, by the law of perpetual change of alternate decay and renovation, depends. Besides these effects, it controls and modifies vitality under every form and feature: in a word, it produces the most important and beneficial effects on the creation, both animate and inanimate. Were it not for its presence, all fluids would be frozen, the ocean would be a quarry of ice, and universal nature stiff and dead.

How are the sensations of heat and cold occasioned?—THEY are produced by the tendency that heat and cold have to distribute themselves in all directions.

How are those sensations produced in the animal system?—THE sensation of heat or warmth is generated when the escape of the natural heat of the system is intercepted, or when some object is placed in contact with the animal body which has a higher temperature than the body, and consequently imparts heat to it; and the sensation of cold is produced when heat is withdrawn from any part of the animal body faster than it is generated in the animal system, by its coming into contact with an object of a lower temperature. The transition of heat from the body, or cold to it, depends on the conducting power of the objects with which it comes in contact, being slow or rapid in proportion to the capacity of the conducting power; an object, which is a good conductor of heat, if it has a lower temperature than the animal body, carrying off heat quickly, when

the body feels cold; but if it has a higher temperature than the body, it communicates heat quickly, when the body feels hot. On the other hand, a bad conductor of heat carries off and communicates heat very slowly; and therefore an object possessed of this quality, though at a lower temperature, is not felt to be colder than the animal body, and though at a higher temperature, is not felt to be warm.

WHY are the approaches of heat and cold gradual in their operation? — To prevent the injurious consequences which would ensue to the condition of the elementary fluids of the animal and vegetable creation by instantaneous changes; the gradual process either in the absorption or the evolution of the caloric principle enabling the various parts of the creation to adapt themselves to the conditions imposed on them.

WHY do some bodies feel warm and others cold, though in a room of the same temperature?—BECAUSE they are either good or bad conductors of heat. Thus, in a warm room, at a higher temperature than that of the human body, a carpet being a bad conductor of heat, transmits no heat, and therefore creates no sensation of warmth to the bare foot or the hand when applied to it; but the marble chimney-piece being a better conductor of heat, transmits heat readily, and feels hot; and the stove and fire-irons being still better conductors than marble, feel still hotter. On the other hand, in a room of a colder temperature than the human body, (namely 96°,) all objects will feel cold in the degree that they are good or bad conductors. Thus the carpet being a bad conductor will produce a sensation of cold; but wood, marble, and iron being better conductors, will produce a sensation of cold in the gradation of their qualities.

WHY does water feel colder to the animal body than air

does?—Because the particles of water in a given bulk are more numerous than those of air, and therefore carry off the heat of the body more rapidly. An additional cause is, that the particles of water are constantly changing their places, the particles which are warmed by the body, immediately ascending by their levity, and cold particles coming into contact with the skin.

Why do sheets feel colder than blankets, or linen sheets and shirts than cotton ones?—Because linen is a better conductor of heat than woollen or cotton, and therefore carries off the heat from the body more rapidly than they do.

What are the comparative advantages of woollen, cotton, and linen clothing, sheets, &c.?—Wool conducts heat but slowly, and readily allows perspiration through its texture; cotton also conducts it in nearly as slow a degree, and being of closer texture than linen, absorbs perspiration, on account of its fibres being finely teethed, its threads adhering closer than the threads of linen, which are destitute of teeth; but linen retaining the matter of perspiration in it, becomes speedily embued with the perspirable matter.

Why does fanning produce the sensation of coolness?—Because by its motion or agitation it is continually bringing fresh particles of air in contact with the skin, and these subtracting the heat of the skin, produce the sensation of coolness.

Why, if we descend into a cave or cellar, do we feel a sensation of warmth in winter and of coolness in summer, though the indications of the thermometer show that the temperature of the place is the same at both seasons?—Because the temperature of the body is higher in summer than that of the cave or cellar, and therefore has its heat abstracted from it by the air

of the place; whereas in winter it is lower, and therefore derives a sensation of warmth from the contact of the air of the place.

WHY are cellars and caves cool in winter and warm in summer?—BECAUSE the earth is a slow conductor of heat.

WHY is not the temperature of cellars and caves proportionately cold to that of the superficial atmosphere of the earth in frosty weather, and why is not the ground in them frozen?—BECAUSE frost penetrates but a few inches below the surface of the earth.

WHAT produces that stifling heat which generally precedes a storm?—THE formation of thick layers of clouds, which becoming an obstacle to the free distribution of radiant caloric, the heat is then reflected from the lower position of the clouds.

WHY do bodies become hot by the action of fire or by that of the sun?—BECAUSE they imbibe a portion of their caloric. According to the force or intensity of the heat produced by fire, the sun, or otherwise, in a relative proportion are bodies deriving their caloric from them heated.

WHY do heated bodies become cold?—BECAUSE the air abstracts or absorbs the caloric imparted to them by means of fire, friction, the sun, or otherwise.

How does the process of cooling proceed?—IT is occasioned by the radiation of heat from the surface of bodies. Moreover, the particles of air in contact with the surface of the body receive heat from it, which, becoming specifically lighter by their dilatation, ascend, and thus, place being given to successive fresh portions of the air, the heat is gradually carried off, until the process of cooling is effected.

WHY do some bodies heat and cool more quickly than others?—BECAUSE of their superior capability of allowing heat to traverse more quickly through them, or to retard its progress.

WHY do hot fluids become cool, and cool more rapidly in proportion as their surface is increased?—BECAUSE their calorie, or principle or cause of heat, escapes by evaporation, consequently their cooling is the more promoted the more that their surface is increased.

WHY do soups, and the contents of pies, puddings, &c. keep hot much longer than thin fluids of the same bulk?—BECAUSE the heat of fluids in general evaporates less readily in proportion to their viscidity or gravity; the diffusing power of the particles of fluids being diminished in proportion as their motion is impeded.

WHY do hot fluids diminish in quantity more rapidly than cold fluids do?—BECAUSE the caloric of the water in its escape carries with it imperceptible particles of the fluid; the more that any fluid is converted into steam, the more rapidly is it diminished.

WHY do hot bodies when immersed in cold fluids become cool quickly?—BECAUSE fluids, on account of the mobility of their particles, receive and transmit heat better than solids do.

WHY do hot fluids, or heated bodies, become more quickly cooled by blowing upon them?—BECAUSE a portion of the air is applied to them which is deprived of its caloric.

WHY is the sensation of cold imparted to the hand when we touch a cold substance, animate or inanimate?—BECAUSE a portion of the heat of the hand rushes into the substance, and leaves the hand proportionably deficient of its former heat.

WHAT occasions the different degrees of heat and cold to be imparted to the touch from substances?—THE different degrees of intensity of heat and cold possessed by substances.

WHY are quacks and mountebanks, when they expose their bodies to fierce temperatures, as when they enter ovens, &c., not burned? — BECAUSE they are clad in woollen dresses, which are bad conductors of heat, and stand upon some non-conducting substance, as a thick mat of straw, wool, &c., and take care to be out of contact of all conducting substances, when the effect produced by the heat of the oven on the meat, fowl, &c. is produced by metal or any other good conductor of heat, which is carefully concealed in a particular part of the oven so as not to be visible to the spectators. Another reason of living matter being more able to resist the impression of heat is, the greater power of attraction which its particles relatively maintain to themselves in their living than their dead state.

*** The following are the most singular among feats of this sort of mountebanking:—

On June 26th, 1828, Martinez, a Spaniard, of Andalusia, clothed in a pair of pantaloons of red flannel, a thick flannel cloak, and a large felt hat, entered, at the New Tivoli, Paris, an oven which had been heated for four hours by a very powerful heat, and remained there seated on a footstool during fourteen minutes while a fowl placed by his side was being roasted. The oven being re-heated he re-entered it, ate the fowl, and drank a bottle of wine. At the end of the seventeenth century, one Richardson cooked a piece of raw flesh upon a burning coal placed on his tongue, swallowed melted glass, pitch, sulphur, and wax mixed together. But Signora

Giradelli, termed the *incombustible* lady, excelled all the fire-feats of fire-eaters: she swallowed boiling oil at the point of 600° Fah.; dipped her fingers into melted lead, and lifting up a portion of it with her hand put it into her mouth, and spit it out in chewed masses. She asserted that she was able to remain in an oven while a leg of mutton was being roasted. To show the imposture of empirics of this kind, Sir William Blagden, Secretary to the Royal Society, remained, accompanied by a dog, during eight minutes in an oven heated to 100° of Reaumur, namely, 20° above the boiling point of water, although the water, covered with oil, boiled close to him; and in thirteen minutes the air being concentrated by a pair of bellows, some beef was dressed in the oven.

WHICH materials are the best adapted for winter-clothing as slow or bad conductors of heat?—FUR and eider down are the warmest materials for winter-apparel; after which, raw silk, sheep's wool, and cotton wool, and then lint or the scrapings of fine linen.

WHY are woollen, flannel, furs, and silk warm, and the best winter clothes?—BECAUSE by means of the air (one of the worst conductors of heat) which is retained between their interstices, they best retain the natural warmth of the human body, by retarding its escape or transmission, being slow conductors of caloric, or, in other words, preventing the emission or conduction of the heat of the body into the surrounding air. For the same purpose that clothing is of use to the human body, animals and birds are clothed by Nature with fur, wool, and feathers; that in the dismal and frightful coldness of high latitudes and the polar regions, the coats of

The metallic reflection and polished surface of the humming bird and of that class of insects termed Lepidopteræ are adapted to the fervid and potent powers of "the land of the sun."

WHY, if water is poured on an iron sieve, the wires of which are made red hot, will it not run through until the sieve cools? —BECAUSE the repellent power of intense heat keeps the water from immediate contact with the heated metal, and the particles of the water, collectively, attain a globular form too large to pass the wires; but when the wire cools, the repulsive power diminishes, and the water coming into closer contact with the heated surface, its particles can no longer retain their globular form, but expand into a state of vapour.

WHY do the feathers of fowls and birds, and the hair of animals, become white in cold weather?—BECAUSE white color best retains the natural heat of the animal body, suffering it to escape but slowly by radiation. In the arctic regions and the high northern latitudes the change is rapid, but in the more temperate climates is proportionately slow, and faint or intense according to the mildness or severity of the season and its early or late advent.

WHY is loose clothing warmer than clothing which fits close?—BECAUSE the escape of animal heat is resisted by the greater quantity of imperfectly conducting air confined round by the clothing being loose than when tight.

WHY is a cold caught by sitting or standing still in wet clothes? — BECAUSE of the abstraction of the heat of the body, which is carried off by the evaporation of the wet in the clothes.

WHAT is meant by a body being a good or a bad conductor

of heat?—Its capacity of emitting or retaining the heat or warmth of another body. Bodies which are good conductors of heat soon carry away the heat from those bodies with which they are in contact; whereas bodies that are slow or bad conductors of heat are those which retard its emission from the bodies with which they may be in contact, in consequence of the air that is between their interstices being stationary.

Which are the best conductors of heat?—The densest bodies. Thus all metallic substances, as silver, copper, gold, iron, and steel allow heat to traverse them more readily than glass, woods, porous and spongy substances, and bodies of a loose texture, as feathers, fleecy matter, &c. which, on account of the quantity of air in their structure, conduct badly. The cause that rooms having double windows and doors are warmer than those with single ones is, that the air contained between the intervals of the doors and windows is an imperfect conductor of heat. The air between the intervals of the double walls of ice-houses produces the same effect; and that effect is increased by introducing straw, saw-dust, or charcoal between the intervals. For the same reason double wine-coolers consist of dŏuble vessels.

Why are the air and the earth not good conductors?—Because the heat of the surface of the earth would be too rapidly carried off, and the vital principle of the animal and the vegetable creation thereby be destroyed. That the earth should be a slow or bad conductor is one of the admirable provisions of the Author of Nature for the purpose of retaining for a sufficient length of time the temperature necessary for the evolution of seeds, and the growth of plants, shrubs, and trees. The best conductors of heat are, as has been just

stated, metals, and then follow in succession diamond, glass, stones, earths, woods, fats or thick oils, snow, air, &c.

WHY is the upper stratum of the water of the sea, rivers, ponds, &c. warmer than the lower strata?—BECAUSE water is a bad conductor of heat.

WHY, when one has a cold in the head, does relief appear to be derived from the use of a silk or cambric handkerchief, while a cotton one irritates the eyes and nose?—BECAUSE the silk, linen, or cambric handkerchief readily absorbing, by conduction, the heat of the nose, diminishes the inflammation; whereas the cotton handkerchief, not being a conductor, resists the passage of the heat, and therefore increases the temperature and the distressing sensation thereby occasioned. The finely twisted fibres of the cotton also contribute to increase the sensation.

WHY are ivory, bone, or wooden handles put to metal vessels, as urns, coffee-pots, tea-pots, &c.?—BECAUSE those substances, being very slow conductors of heat, interrupt its communication to the hand.

WHY are polished metal tea-pots and coffee-pots preferred to earthern or china ware for the making of tea?—BECAUSE smooth and polished surfaces retain heat better than dark and rough surfaces; and metals being slower conductors of heat than earths are, (that is, they emit it more slowly from their surfaces,) hot water continues at a high temperature much longer (eight times) in a metal tea-pot than in an earthen or china ware one. For the same reason the lid or upper surfaces of kettles, pots, &c. should be kept bright and their bottoms black, in order that the tops may retain heat and the bottoms absorb it.

WHY does putting a small quantity of boiling water into a tea-pot, before the introduction of the tea, promote the extraction of the properties of the tea?—BECAUSE it prevents the cold condition of the pot extracting part of the caloric of the water necessary to heat it. The reason is the same that it is politic to place the tea-pot upon a woollen rug, namely, to prevent the coldness of the tea-board detracting from the caloric of the tea-pot, as also to preserve the temperature of the tea-pot. Covering the tea-pot with a woollen case contributes to preserve the temperature of the water.

WHY do we feel the sensation of heat or burning if we touch hot substances, as hot iron or scalding water, or that of cold from ice or stone?—BECAUSE in the first case the temperature of our bodies being less than the heat of the iron or of the water, they draw a portion of their caloric or heat from them; the heat of the substance rushing into the hand according to the intensity of the caloric possessed by the substance; and in the second case our bodies, being of a higher temperature than the ice or the stone, a portion of their heat or caloric is drawn from them.

WHY, when we wash or bathe in warm water, do we experience the sensation of heat, when in cold water that of cold?—BECAUSE, in the first case, our bodies draw heat or caloric from the water, and in the second case their heat or caloric escapes from them.

WHY does water appear colder to the hand than a solid body (namely, stone, marble, or iron) of the same temperature; and why does water appear colder to the hand when the hand is moved about in it than when it is kept motionless in it?—BECAUSE of the mobility or constant change of the

particles of the water, the fresh particles which come into contact with the hand abstracting or absorbing its warmth. It is for this reason that the cold of winter is more severely felt when wind prevails, and on the other hand that the accumulated ice and snows of winter rapidly melt when the warm south winds of spring begin to blow upon them.

WHY do two substances become heated by friction, or by being rubbed together?—BECAUSE by the friction, or being rubbed together, the air, being heated by its compression, imparts in its escape a portion of its heat or caloric to them. It is by friction, after a long continuance of dry weather, that forest-trees take fire, and that the extensive forests that are spread over the continents of America are sometimes in conflagration.

WHY does heat melt or render metals fluid, but reduce other substances, as wood, &c., to ashes?—BECAUSE the gas contained in the pores or interstices between the several particles of metals, when excited by heat, produces an expansion or distension of the various particles of which they are composed, and thus the attraction of cohesion being overpowered, the parts separated become reduced to a fluid or liquified shape; but the humidity of wood, &c. being expelled by heat, such substances are reduced to dry grains. If the heat, however, be further exerted, the dry grains will be reduced into a fluid state resembling glass.

WHY does heat lengthen and thicken, or increase the size of metals?—BECAUSE the fluid of heat which, as one of the constituent principles of nature, is lodged among the atoms of matter of which they are composed, pressing outwards on all sides, expands or dilates them proportionate to the extent

of the excitation which has been applied to them. It is from this cause that the gates of iron railings are difficult to shut in summer, and that the arches of iron bridges lengthen in summer and contract in winter, and therefore require a compensating provision in their construction.

WHY does cold contract or diminish metals?—BECAUSE the gas or air contained in the interstices that exist between their several parts, being rendered denser by the cold, and the size of the interstices being consequently diminished, the surrounding particles of the metal are thereby allowed to approach nearer to one another, and thus the contraction of the metal is occasioned.

*** It is for the reasons stated in the two last solutions that clocks and watches vary in going in summer and winter, a variation in the length of the pendulum and the balance wheel taking place with the change of temperature;—that in summer house-bells fail to ring when pulled;—that harps and pianos tuned in the morning are out of tune from the heat of the room produced by a crowded evening party;—that a bar of iron becomes longer and thicker when made hot than it was when in a cold state;—that air and water increase in volume by heat;—that the iron rim of a wheel slips easily into its place, or an iron hoop on a tub, when hot, but in each case gripes or binds fast when it is cool;—or that iron, when hammered, increases in volume: the pendulum, balance wheel, wire, string, and iron having in each case expanded or contracted according as the temperature was hot or cold. The reason of the application of hot tires of iron for carriage-wheels, and hot iron hoops for casks, is, that the iron, when cool, contracting, binds the rivets of the wheel and the staves of the cask closer and more strongly. On the same principle spirits

are expanded in bulk or increase in quantity in summer, but are condensed, or are of less bulk, in winter; that a cup or glass will hold more liquid in a hot state than when the liquid is of a cold temperature: and thus appears the cause why, when a cup or other vessel has been filled to the brim with hot liquid, the liquid when cool appears less in quantity.

WHY do wood and clay shrink and diminish by heat, but swell and expand by moisture?—BECAUSE heat carries off the watery parts from them, and thus allows their constituent atoms, which had been expanded by its presence, to collapse or come more closely together.

WHY is not wood into which a large nail has been driven increased in size in the same manner as an additional spoonful of water poured into a basin already full causes it to overflow?—BECAUSE the porosity of the wood allows its constituent particles to be compressed or squeezed closer together.

WHY does wet or moisture shorten some bodies, as hemp, linen, cotton, silk, worsted, flannel, cord, catgut, &c., while other bodies, as wood, paper, parchment, leather, and animal membranes are lengthened by humidity?—BECAUSE in the first case the vapour or humidity penetrating the bodies, swells and thickens them; and in the second case it extends them. It is on account of the first-mentioned of these causes that the strings of musical instruments, when strung tightly, break in moist weather, as their tension is increased; that stockings put on dry are difficult to pull off when wet. By the second-mentioned cause, paper stretched on a frame becomes slack, and wooden gates become difficult to shut. On the same principle the little figures placed on the tops of weather-houses indicate the state of the atmosphere, or foretel dry or wet

weather, according as the piece of catgut which is attached to them stretches or contracts.

How can it be proved that metals expand by heat, and wood by moisture?—An iron bar, when heated, cannot be made to enter an opening which, when cold, it will readily enter. The gate of an iron railing which in cold weather will shut and open easily will sometimes stick fast on a warm day, on account of there being a greater expansion in it and the neighbouring railing than of the earth in which they are fixed. For the same reason the centre arches of iron bridges are higher in hot weather than they are in cold weather; a property forgotten to be noticed by the architect in the erection of Southwark cast-iron bridge, which oversight occasioned great damage to the bridge, as the extreme variations of atmospheric temperature occasioned a difference of height in the arches at different seasons amounting to about one inch. The same principle extends to many metallic instruments, as the pendulums of clocks, the balance-wheels of watches, &c. they being affected by the change of seasons and their removal to a warmer or a colder climate. By the same cause also musical instruments are out of tune, the expansion of the strings being greater than that of the wooden frame-work of the instrument. The reason that wooden gates stick fast in wet weather is, that they are more swelled with the wet than the earth is on which they stand.

*** The change or variation produced in bulk to wood and metals by the vicissitudes of temperature is not peculiar to them; for all solid bodies are subject to the same change of magnitude from the same cause. When the weather is cool they shrink and contract their dimensions, but when the

temperature of the weather increases their dimensions become enlarged.

WHY are the sun's rays considerably hotter on the floor of a room than they are on the glass through which they have passed?—BECAUSE the resistance offered by the glass to the sun's rays is considerably less than that presented by the floor.

WHY do the colors of clothes, curtains, &c. when exposed to the sun's rays, fade?—BECAUSE the oxygen which existed in the color in a solid form being rendered aëriform by the sun's rays has disappeared in the form of oxygen gas.

WHY does hot water sooner penetrate and dissolve substances than cold water does?—BECAUSE it is in a greater state of activity, and consequently more readily insinuates itself into bodies or materials, and produces in them a greater excitement.

WHY does a hot bar of iron sooner cool when exposed to the force of a powerful sun than when laid in a cool place?—BECAUSE the air being expanded and rarefied by the action of the sun, does not supply the iron with so much nourishment as when the air is cool.

WHY does a drop of water roll about upon a red-hot iron, and remain tranquil in a very hot silver tea-spoon, and not evaporate until the temperature of the metals decreases?—BECAUSE a film of vapour intervenes in each case between the metal and the water, and thus preventing their contact interferes with the transmission of the heat to the water, and retards the evaporation.

WHY do fires burn brighter and more ardently in frosty or intensely cold weather than in summer or warm weather?—

BECAUSE cold oxygen being more dense affords more nourishment to fire than warm oxygen.

WHY is an exhausted fire revived by laying an iron poker upon it?—BECAUSE the poker collects and concentrates the heat and thereby creates a draught through the fire.

WHY is fire revived by being blown?—BECAUSE that part of it which is in a state of combustion is supplied with a greater quantity of oxygen than it could obtain by its own action on the surrounding air.

WHY is a fire revived and supported by a draught of air flowing towards the fire-place?—BECAUSE a supply of caloric is furnished without intermission, till the whole of the combustible matter is saturated with oxygen.

How does fire, whether in a stove or placed upon the ground, impart its influence to the surrounding air?—BY rarefying the air; and this it does by throwing off the heat in rays or straight lines in all directions, until it is equally diffused through the apartment by the motion produced in the air.

WHY do a large pair of bellows bring up a fire quicker than a small pair?—BECAUSE they carry a larger portion of air to the fire, and consequently furnish it with a larger portion of oxygen.

WHY is a fire nearly extinguished quickly ignited and drawn up by applying before the fireplace and the upper part of the stove a blanket or other covering?—BECAUSE a draught of air is thereby directed to the fire.

WHY by closing up the fire-place and the chimney-pot is a fire in a chimney extinguished?—BECAUSE the air which supports the fire is extinguished.

WHY is a fire extinguished by throwing a handful of sulphur upon it?—BECAUSE the sulphur, like water, decom-

poses the inflammable property of the air; that is, the sulphur combining with the oxygen of the atmosphere fills the chimney with sulphureous acid gas, which, arresting the combustion of the carbon forming the basis of the soot, thus extinguishes the fire.

WHY is fire extinguished by water?—BECAUSE the water by the decomposition of the hydrogen or caloric of the air neutralizes its action, and therefore deprives the fire of its natural fuel.

WHY does not a small quantity of water extinguish a large fire?—BECAUSE the power of the fire is greater than that of the water; its intenseness decomposing the constituent parts of the water, namely, the oxygen and the hydrogen; thereby adding fresh fuel to the flame.

WHY does water thrown on a brisk and flaming fire apparently increase the combustion?—BECAUSE of the conversion of the water into steam, which expanding and mixing with the flame causes the flame to spread out for a few moments to a much larger volume than it previously occupied.

WHY, while fire is lighted by being blown, does blowing upon the flame of a candle extinguish the light?—BECAUSE the flame in the wick and the gas or vapour of the unctuous material are scattered or dissipated by being blown upon.

WHY will not fires burn when the rays of the sun shine on them?—BECAUSE the rays rarefy or disperse the oxygenic principle of the air which is the support or nutriment of the fire.

WHY does a large fire extinguish a small one in the same room?—BECAUSE it robs the small one of the draught of air which feeds it.

WHY do fires burn brightest at night?—BECAUSE of the exclusion or absence of their great rival, light.

WHY is a rush-light extinguished by sticking a pin into it?—BECAUSE so much heat is conducted away by the pin as to prevent the tallow from melting or rising in the wick.

WHY by immersing in warm water the neck of a bottle in which a glass stopper is immoveable, or by surrounding the neck with a cloth which has been dipped in hot water, can the stopper be loosened?—BECAUSE the part of the neck of the bottle which holds the stopper fast is expanded by the heat, and thus is rendered loose about the stopper.

WHY are fish and other marine animals not destroyed by the frost in winter?—BECAUSE the water immediately beneath the ice, being a bad conductor of heat, prevents the escape of the temperature of the water at the lower parts of the sea, rivers, or ponds, and thus forms a barrier impervious to the cold of the congealed surface.

WHY do ricks of hay, packages of coffee, bales of cotton, masses of coal, and other articles, spontaneously inflame or catch fire?—BECAUSE all bodies containing carbon, having an avidity to contract moisture or absorb air, whenever such bodies are put into masses in a moist state, or that water, rain, or air gets to them, an augmentation of temperature ensues; and consequently, as an elevation of temperature generally promotes the chemical action of bodies, a spontaneous inflammation or combustion of them takes place.

*** As the cause and origin of many fires cannot be accounted for, and the criminal annals of the country contain many cases where the unfortunate sufferers appear to have been the victims of misguided justice and ignorance of the causes of spontaneous combustion, it may not be useless to state here that fires have often been occasioned by the spontaneous combustion of hay, corn, flax, cotton, wool, turf, flour, saffron,

oatmeal, roasted coffee, and other vegetable substances, by having been laid by in a damp state, or having accidentally become so. Rags, coal, charcoal, unslaked lime, bales of woollen cloths and cotton goods, floor cloth, pyrites, waste cotton or rag, have also ignited from the same causes. Waste cotton or rags used in cleaning with oil, hemp oil, and various other self-enkindling substances, have been the cause of spontaneous fire.

WHY does a candle or lamp burn?—BECAUSE the hydrogenous substance in the tallow and oil, and which is evolved by the burning when raised to a proper temperature, absorbing the oxygen of the surrounding atmosphere, combines with it.

WHY does the tallow or wax of a candle when lighted ascend up the wick?—BECAUSE it is absorbed by the heat of the flame through the interstices of the wick.

WHY does the flame of a candle burn in a conical shape?—BECAUSE vapour being of less specific gravity than the air, being ignited it rises upwards in the form of a tube or cone of fire, and as the vapour with which the cone is filled is not inflamed, but gradually consumed as the vapour rises, the cone is also gradually lessened in its dimensions until its form is fully completed.

WHY do some lamps burn without a wick?—BECAUSE the oil being raised through a small tin tube, the oil, on becoming hot, is decomposed, and gas generated as long as any oil remains in the basin of the burner. It is on this principle that the Argand or patent lamp is constructed, air being admitted into the hollow of the flame while the oil is in a state of combustion.

WHY does a candle or lamp smoke?—BECAUSE the heat which it produces is not sufficient to effect the total combustion of the carbon which rises in the flame.

WHY is the light of a lamp improved when surrounded by a glass tube, and its wick smoke but little?—BECAUSE the effect of the principles of the oil which generate the flame is concentrated within the glass, and thus those principles are more effectually consumed than they would be if consumed in the open air.

WHY do burners containing many wicks placed near one another supply more light than would be produced by the same number of wicks in separate lamps?—BECAUSE many wicks impart heat to each other; light emitted by a body in combustion being in proportion to the elevation of the temperature.

WHY does a lamp or candle smoke when the wick is cut or snuffed unevenly?—BECAUSE the gas or vapour of the oil or tallow escapes more abundantly at the long part of the uneven incision of the wick, and not reaching the centre of the flame is not entirely consumed.

WHAT occasions street lamps, after a foggy night, to be seen burning at a late hour next morning?—THE combustion of the oil or gas in the lamps has been diminished by the effect of the fog, damp or misty air not supplying oxygen so readily as clear air.

WHAT occasions heated platinum wire placed round the wick of a spirit lamp to supply light and heat, though without flame?—THE vapour of the spirit consumed, the heat of which is never sufficiently intense to produce inflammation.

WHY do candles and lamps "spirt" when rain is at hand?—BECAUSE the humidity of vapour with which the air is filled penetrating the wick, and suddenly expanding, produces a slight explosion, which occasions the "spirting."

WHY does the flame of a candle or torch appear to increase the farther it is removed?—BECAUSE the particles of the addi-

tional fresh air that surround the flame become luminous and blend themselves with the light.

WHY does flame, though of a pyramidal form when near, assume the appearance of a circular form when distant?—BECAUSE the illumined air when surrounding the flame and produced by its reflection appears to be blended with it; whereas when flame is near, it is seen in its real pyramidical form, as its rays overpower in splendour those produced by their reflection on the surrounding air.

WHY is a large body of flame seen at times on the top of the chimney of a foundry furnace?—BECAUSE the heat of the furnace is so great that the smoke becomes ignited on coming into contact with the oxygen of the atmosphere.

WHY do covered lamps give a better light than open lamps? —BECAUSE the unctuous materials of the oil or tallow are more effectually consumed.

WHY is smoke produced from combustion?—BECAUSE of the absence of the necessary quantity of heat to produce perfect or complete combustion of the material employed. This arises from the following cause:—When fresh fuel is placed on a fire it is subjected to a distillation, which will be complete or otherwise according to the manner in which it is placed on the fire. When the quantity is such as to damp the activity of the fire, and is so placed as to allow of a slow coking of the fuel before the distillation has proceeded far, then its gases are likely to be pretty fully consumed. When the circumstances are directly the contrary, the gases fly off, mixed with particles of the fuel itself, and volumes of smoke are seen to arise from the coals. The improvident loss appears from the fact, that the gases arising from ordinary coal contain about 38 per cent. of the whole heating power of the coal.

Of what does smoke consist?—Of the vapour produced by combustion from the moisture of the fuel, and the carburetted hydrogen and bituminous substances formed during combustion by the union of the hydrogen of the combustible substance with the oxygen of the atmosphere.

Why is it wasteful to wet coal?—Because the moisture, on being evaporated, latently carries off with it the heat produced by the combustion of the coals.

How is flame produced?—By the rapid combustion of volatilized matter.

What is flame?—A portion of the combustible matter converted into vapour of a white heat.

Why does the centre of the flame of a candle appear not so white as the outward part?—Because the outer portion of the flame prevents the inner or centrical portion from coming into contact with the oxygenic principle of the air, which is the supporter of combustion.

Why does the centrical portion of flame appear lighter at the top than it does at the bottom?—Because the body of the vapour being thinner there than it is at the bottom, it has come into closer contact with the oxygen of the atmospheric air.

Why is the quantity of water found in a glass vessel of a globular figure, in which a candle has been burned, of greater weight than the candle was?—Because of the increase produced from the quantity of oxygen which has been consumed during the combustion of the candle.

Why does smoke ascend?—Because the air surrounding the fire being rarefied or made lighter by the heat has a tendency to rise, and drawing the smoke, which is specifically lighter than the air, after it, carries it upwards.

Why does smoke when formed into soot fall or descend?—

BECAUSE the particles of smoke suspended in the air uniting become heavier than the air.

WHY are vast columns of black smoke and vapour seen at times coming out of the tops of chimneys?—BECAUSE too large a quantity of fuel has been thrown upon the fire, which not being inflamed properly by the heat of the fire, its particles are thrown off in that form, thereby occasioning a great loss of fuel and heat.

WHY is a nuisance avoided, and a saving of fuel effected, by destroying or burning smoke in smoke-consuming stoves?—BECAUSE the heat formed by the combustion of the hydrogen contained in the coals, and which would have escaped in the form of gas in the open stove, is condensed and preserved for recombustion, thus effecting a saving and preventing any unpleasant smell.

WHY do not coke and charcoal fires smoke?—BECAUSE the moisture has, by the reduction of the wood and coal from which those substances have been produced, been previously dissipated in their preparation.

WHY does charcoal readily burn?—BECAUSE the mutual cohesion of the particles of which it is composed having been weakened by the charring, its component particles are so repelled and separated from one another that they have an affinity with the oxygen of the surrounding air.

WHY, after its preparation, does charcoal increase in weight on exposure to the air?—BECAUSE from its hygrometric property it absorbs air and moisture in considerable quantities.

WHY do ignited sparks of wood and cinders fly out of the fire during the combustion of wood and coals?—BECAUSE the air in the pores of the wood, or between the particles of the pieces of coal, becoming expanded by the heat, throws out in

sparks and cinders that portion of either commodity that opposes its passage.

WHY do coals burn, but stones not?—BECAUSE coals contain oxygen, which is inflammable, but stones do not contain any gas of the kind.

WHY, if oxygen is the constituent principle of combustion, do not coals, wood, and other combustible substances take fire on exposure to the air?—BECAUSE all such bodies, and even inflammable ones, require the application of heat, friction, or moisture, to produce the requisite preparatory temperature before they will combine with the oxygenetic principle of the atmosphere.

WHY are cinders and ashes of less weight than the coal or wood was from which they have been produced?—BECAUSE the greater part of the particles of which they were composed have been consumed in vapour, as smoke and invisible gases.

WHY do bodies, as coal, wood, &c., when burnt, become less?—BECAUSE by the combustion the difference between the amount of the original particles of matter and those of the residue has been evaporated in the form of smoke and vapour.

WHY do metals increase in weight when subjected to combustion?—BECAUSE of the absorption of oxygen which takes place during the calcination. The cause is the same that the ashes of substances in the combustion of which no diminution takes place by dissipation in fumes, are heavier than the substances were from which they were produced.

WHY does black paint hasten the decay of wood when exposed to the weather, while white paint tends to its preservation?—BECAUSE, 1st, black paint possesses less body than white paint; and 2ndly, that black paint absorbs heat,

while white reflects it: the consequence of the absorption is that the pores of the wood expand, and it therefore shrinks and splits.

WHY is wood reduced by combustion to a smaller quantity of ashes than an equal quantity of coal is?—BECAUSE wood contains more air and humidity, which evaporates in the form of smoke.

WHY will not cinders which have been burned twice or thrice burn again?—BECAUSE they have been fully saturated with oxygen, so as to unfit them for combustion, by the decomposition of the oxygen of the surrounding air.

WHY will not wet wood, linen, paper, &c. burn?—BECAUSE the aqueous steam arising in the fire from those substances smothers the flame and scatters the heat of the fire.

WHY, when green wood or wet coal is thrown on a fire, does the fire burn dull and its heat become feeble?—BECAUSE the wet which they contain abstracts the heat of the fire in order to convert the moisture they contain into steam, before they are capable of combustion.

WHY does the collision of a flint and steel produce sparks of fire?—BECAUSE by the collision the particles of the flint and the steel which are detached are vitrified and ignited; other substances besides steel will produce ignited sparks when struck with a flint.

WHY does partly opening a door or window, when a chimney smokes, clear the room of smoke, and compel it to ascend the chimney?—BECAUSE the current of air thus produced repels the smoke, and compels the rarefied air surrounding the fire to ascend the chimney.

WHY, when the door of a room is opened, and a candle held in the doorway, will the flame be blown inwards at

the bottom, but outwards at the top?—BECAUSE there are two currents of air; viz. the lower current inwards at the bottom, being the external air rushing into the room; and the upper current outwards at the top of the door, being the internal air of the room rushing out.

WHY does water simmer before it boils?—BECAUSE it is agitated by the particles of air contained in it being expanded by the heat, and their endeavour to remove the water which impedes their expansion and ascension.

How does water boil?—The boiling of water is produced by the cold stratum of water at the bottom of the vessel being expanded by the heat or caloric of the fire, when becoming specifically lighter than the water above it and the common density of the water, it ascends according to the general principle of hydrostatics, and the colder and heavier stratum immediately above it descending, an interchange of place ensues between it and the lower strata of water; and this interchange of position continues to take place between the various strata of the water as long as the lower strata receive increased temperature, constant currents upwards and downwards being continued until the liquid reaches the temperature of the boiling point; every particle of the water in the vessel in its turn having come in contact with the bottom and received heat from it. It is on this account that water is warm at its top or upper stratum, while that portion of it which is at the bottom of the vessel remains cold until the whole contents of the water in the vessel have reached the boiling point; the warm particles expanding as they are warmed by the heat, and thus becoming specifically lighter than those which compose the common density of the contents, rising to the top, while the cold and heavy particles which composed the upper stratum sink to the

bottom, to be heated and rise in their turn, until the whole mass has reached the temperature of the boiling point.

WHY does water, heated on its upper surface, require longer time to attain the vaporific point than when heated in its lower strata?—BECAUSE heat penetrates with difficulty through the upper stratum of warm liquid to reach that which is beneath.

WHY is that agitated appearance on the surface of water produced, called bubbling or ebullition?—BECAUSE the lowest stratum of the water being converted into steam by the heat or caloric of the fire, and this steam forming in the shape of bubbles at the bottom of the vessel (which are many hundred times lighter than the rest of the liquid), will rise with great rapidity to the surface, where, in their attempt to escape into the air they repel and agitate the surface of the water in the form of bubbles, and the bubbling or ebullition is increased with a force proportionate to the intensity of the fire.

WHY will not water increase in heat beyond 212° of temperature, or become hotter when it has once boiled?—BECAUSE the excitement of the motion of its particles occasioned by boiling is diminished, or escapes by evaporation or steam (which it does when heated to the boiling point) as fast as the excitement which produces boiling is increased.

WHY does water boil with a less quantity of fire on a mountain than it does on a plain?—BECAUSE as in elevated places the air is less dense than in places where the atmospheric pressure is less on the water; the caloric that introduces itself into the heated water, consequently, finds a greater facility in displacing the particles of the water. Water boils on plains at 212° Fah., and on the summit of Mont Blanc at 187°. Science, availing itself of the fact, calculates the height of

mountains from the atmosphere at which water boils upon their summits.

Obs. The congelation of water is subject to a different law to that of all other fluids; the latter expand uniformly by an increase, and contract by a diminution, of temperature from their freezing to their boiling points, or vice versâ; whereas water, when its temperature is reduced below 40° Fah., increases in volume in the same ratio as when its temperature is elevated above 40°.

WHY does a kettle placed over a bundle of lighted wood boil sooner than when placed over a coke or coal fire?—BECAUSE the flame is more intense; and this arises from the greater motion of the heat produced by wood than that produced by coal, the intensity of heat being in proportion to its motion. It is for this reason that hot water appears hotter when the hand or foot is rapidly moved to and fro in it, than when kept still or motionless.

WHY should the bottoms of kettles, pots, and saucepans be allowed to remain black, but their lids and tops kept polished?—BECAUSE black and rough surfaces absorb heat, and polished ones ensure the retention of heat.

WHAT occasions iron boilers to burst?—THE rapid formation of bubbles at those points against which the flame is most strongly directed; when, in the process of boiling water, the heat overcomes the atmospheric pressure on the surface of the water, then if any particular portion of the surface of the boiler be more intensely heated than the surrounding parts, the abundant formation of bubbles will drive off the water from the inner surface of that portion of the boiler, and thus the metal becoming irregularly heated, when the water comes again in contact with it, very elastic steam being formed, occasions the boiler to burst.

WHY does the boiler of a steam-vessel burst?—BECAUSE the safety valve not being opened to emit the steam, the body of air contained in the boiler having become so expanded by the heat as to require a greater space than its dimensions afford, bursts the boiler.

WHY do bottles containing liquids, when put near the fire, burst? — BECAUSE the air they contain becoming rarefied requires additional room for its exhaustion; or that the outer surface of the bottle becomes heated, while the inner surface remains cold.

WHY do bottles containing liquids sometimes burst without any apparent cause?—BECAUSE the liquids contained in them produce air which, combining with the air contained between the cork and the surface of the liquor, occasions an increased internal pressure upon the bottle, either forcing out the cork or breaking the bottle.

WHY does glass or china crack by putting hot water into it? —BECAUSE the water occasions a sudden expansion of the inner or interior surface of the glass or vessel; but the heat or caloric not passing sufficiently quick to equally expand the outer surface, the irregular expansion causes the vessel to break; and the danger is increased in proportion to the thickness of the glass or vessel. In the same manner the glass chimneys used for oil lamps and gas burners are often broken; but the danger of fracture may be prevented by making a minute notch in the bottom of the tube with a diamond. The reason that when the glass or china is thin it is more liable to be broken by boiling water than when thick, is that thick vessels do not allow so ready a passage to heat as thin ones.

WHY does a bladder swell and become filled out, or a rotten apple become plumped out, when put near the fire?—BECAUSE

the air contained in them becomes expanded; if the degree of heat applied to them be too great, they burst.

WHY is gunpowder of a small grain or granulation necessary for fowling pieces, pistols, &c., and that of a coarse grain for artillery?—BECAUSE gunpowder of a small grain or granulation contains a greater number of interstices than that of a large size, and therefore presenting a greater amount of surface to be acted on by inflammable fluid explodes quicker than gunpowder of a large grain or granulation.

WHY is gunpowder of a large grain or granulation requisite for artillery?—BECAUSE, as gunpowder to be a propellant, or to enable it to act with the requisite projectile force, must be moderated in its explosive tendency by being made of a grain proportionate to the size of the propellant medium, powder of a large grain or granulation is necessary in order that the grain may burn longer, to give out fresh explosive matter, to enable a large mass of projectile to be put into motion, and continue the generation of force until it has reached the highest state of velocity to acquire the necessary range.

WHY is gun-cotton more efficient than gunpowder, being more powerful in effect and more rapid in explosion?—IT has a more powerful effect, because it presents a greater amount of surface to the action of the explosive fluid, by the more perfect incorporation of the explosive agents, nitre and charcoal; and it is more rapid in its explosion than gunpowder, because it fills a great space by the expansion of the air within its comparatively greater number of interstices.

WHY does not gun-cotton when exploded over gunpowder ignite it?—BECAUSE the explosion arising from the minuteness of the particles of the gun-cotton brought into contact with the heating agent, does not endure sufficiently long to

raise the particles of gunpowder up to 600 degrees of heat (its explosive condition); the explosive power of cotton wool being at 400 degrees of heat.

WHY is steam better calculated for the discharge of artillery and the throwing of projectiles than gunpowder?—BECAUSE the elastic and projectile force imparts to the ball or projectile a much greater range than that of gunpowder.

WHY do drops of water appear on plants and flowers in fine spring and autumnal nights?—BECAUSE the vapours that arise after sunset being condensed by the freshness of the air, fall again to the earth, and thus collect themselves upon the leaves of plants and flowers.

WHY are the insides of windows covered in the winter with rime frost?—BECAUSE the air in the room being warmer than the external air is attracted to the glass, and thus losing its heat or caloric is converted into rime frost.

WHAT produces the radiant and tree-like crystallizations on the dirty panes of glass of windows in London?—THE sulphate of ammonia produced in the atmosphere by the coal fires of the metropolis.

WHY do bottles containing iced wine or any cold liquid appear covered with steam or fine drops of water when placed in a warm room?—BECAUSE the aqueous vapour of the surrounding air is condensed upon it, and the evaporation will continue until the water becomes of the same temperature as the air of the room, however often the steam or drops of water may be wiped off. The small vesicles of water that appear on the inside of a bottle containing a portion of liquid have been produced by the evaporation which the heat of the place where the bottle is placed has occasioned.

WHY does wrapping wet cloths round bottles of wine in

warm weather, or placing them in iced water, or in porous wine-coolers dipped in water, cool the wine?—BECAUSE an evaporation of warmth or heat is thereby promoted, for as the dampness of the cloth or that of the wine-coolers evaporates, the cloth loses its heat or caloric, and the caloric of the wine is drawn to it through the bottle.

WHY does water by being exposed to the sun become soft?—BECAUSE the rays of the sun acting on the carbonic acid gas which the lime present in the water has generated, absorb the expanding vapour from the water, and thus free it from the particles of lime, which are precipitated to the bottom of the water.

WHY do watches and clocks lose and gain time?—BECAUSE, among other causes, their works are subject to the vicissitudes of heat and cold to which they are exposed. When the pendulum or balance-wheel is lengthened or enlarged by heat, it swings more slowly, and its rate of movement is diminished; but when it contracts by cold, its vibration is accelerated, and the rate of movement is increased. Every four degrees of the thermometer will cause a variation of one second daily, and the difference of the going of a clock in summer and winter will be about six seconds a day or one minute in ten days.

WHY does a compensation-balance prevent the effects of expansion and contraction?—BECAUSE the expansion of one of the interrupted concentric rings of different metals of which it consists, counteracts the expansion of the hair-spring, and vice versâ.

WHY do some wells smoke in winter?—BECAUSE the water being of a higher temperature than the superincumbent air, it rises in the form of steam.

WHY does the breath or perspiration of men and animals at times appear as a volume of steam or vapour issuing from their mouths?—BECAUSE the breath, which when the air is warm

issues from the mouth imperceptibly, is thickly condensed and precipitated by the cold air.

WHY does the spout of a kettle in a boiling state emit a thick column of vapour?—BECAUSE the water is beginning to become dense, and emitting its finer particles from the spout the vapour in reaching the air becomes so dense as to be visible.

WHY does ice by being heated become water, and the water, by the continuation of heat, become steam?—BECAUSE by heat the mutual distance of the constituent particles of the ice is increased, and their cohesive attraction overcome, and when the atoms are repelled to greater distances, they are converted into steam. A pint of water converted into steam will occupy nearly two thousand times its original space.

WHY do fish and meat quickly become spoiled by the beams of the moon?—BECAUSE in bright moon-light nights substances radiating their heat freely soon become covered with dew, and thus is occasioned the morbid influence of the moon on those substances, the presence of moisture rapidly promoting the decomposition of all animal matter.

WHY do putrefying animal bodies appear to be surrounded with a luminous light?—BECAUSE they are beginning to become decomposed and to produce hydrogen compounded with carbon, sulphur, and phosphorus. For the same reason, namely, from the presence of phosphorus, the luminous appearance in the sea in the wakes of ships, that of fire-flies in the night, and of blazing meteors, such as ignes fatui, &c. are produced.

WHAT occasions the spontaneous combustion which occasionally occurs in the bodies of animals, both human and dumb?—THE extrication of phosphurated hydrogen gas which has been generated in the body. The whole fabric of the body of the person (or when pigs have been fed on distillers' wash,

or been in the habit of drinking by stealth the spirit) is so charged, by the constant practice of spirit drinking, with inflammable matter (probably hydrogen); or, chemically speaking, it acquires so powerful an attraction for oxygen, that it suddenly takes fire (in some cases instantaneously, in others from the heat of fire, the light of a candle, &c.) and the body is reduced to a cinder. The persons on whom this dreadful visitation of apparently supernatural punishment for the violation of the laws of nature has occurred, have been chiefly women. In some cases the unhappy sufferers have been found burning, "sometimes with an open flame flickering over the body, and sometimes with a smothered heat or fire, without any open flame whatever;" and the application of water has occasionally seemed rather to quicken than to impede the combustion. In no instance has the fire or flame thereby excited in the body been so powerful as essentially to injure the most combustible substances immediately in contact with it, as the linen of the bed furniture, &c. The phenomenon has usually taken place in the night, when the sufferer has been alone, and has commonly been discovered by the fœtid penetrating scent of sooty films which have spread to a considerable distance. The unhappy sufferer has in every instance been found dead, being more or less completely reduced to ashes. Numerous instances of this singular phenomenon, and awfully supernatural visitation for the violation of the laws of nature, are recorded in Dr. Mason Good's "History of Medicine;" "The Cyclopædia of Medicine," edited by Drs. Forbes and Conolly; Dr. Young's "Medical Literature;" Vols. 63 and 64 of the "Philosophical Transactions;" and in a variety of foreign journals, medical as well as general. See also an instance in the Medical Journal, 1830.

WHY, in fine, calm, and clear nights is the sensation of cold more intense than in dark and cloudy nights?—BECAUSE the heat radiated from the earth is not reflected back again as it is in dark nights when the sky is overcast with clouds, which then partake of the property and form of a concave mirror, and reflect the heat radiated from the earth back to its surface, and thus tend to keep the air warm.

WHY in clear and calm nights is the temperature of the air greater in the open country than it is in towns?—BECAUSE the radiation of heat from the earth's surface in the country proceeds without interruption, whereas in towns it is in some measure reflected back from the houses and buildings.

WHY, while snow is melting during a thaw, does the air feel warm?—BECAUSE the snow in its consolidation into flakes imparts its heat to the air.

WHY is the surface of the ground chillier during a thaw than at any other time?—BECAUSE the melting of the snow then greedily absorbs heat from surrounding objects.

WHY does a halo round the moon indicate the approach of wet weather?—BECAUSE it is a collection of water which has been precipitated around that planet.

WHY do bright sunny mornings often precede rain?—BECAUSE the moisture accumulated in the air has obtained a higher refractive power and acquires increased brightness and transparency.

WHY do red clouds in the west, at sunset, portend fine weather?—BECAUSE the air when dry refracts more red or heat-making rays.

WHY are some summers hot and dry, others cold and wet?—THE cold and wet summers are occasioned by the ice, which is liberated from the northern latitudes, in its passage towards the equator cooling down the temperature of

the water, and the air passing over its surface condenses the atmospheric moisture, and thus reducing the temperature of the seasons, produces rain and cold. The hot and dry summers are the result of but little new ice having been formed in the high latitudes. The cause of severe winters is the extension of the Gulf Stream to those localities where the winters are remarkable for their mildness. That stream, in general, terminates about the meridian of the Azores; but in the winters 1821–1822 and 1845–1846 it extended to the coasts of Europe, which circumstance was the cause of the severe winters of those years.

WHY are some countries hotter than others, or what occasions the difference of climate?—BECAUSE the heat of the sun depends on its being more or less directly vertical or over head; that is, the greater or less intensity of the heat produced by its rays is occasioned by the different directions, (namely, whether perpendicular or slanting,) which the rays of light take in reaching the earth. When the solar rays fall directly or vertically in their descent on a particular spot or district, they radiate or give out much greater heat than when they fall obliquely; for by their direct or vertical direction they fall with more force, and a greater number of them is included in a given space; whereas when their direction is slanting or oblique, they do not produce the same intensity of heat, as the rays are not only of inferior power, but are more scattered, and fewer of them strike a given spot or district. Thus is produced the difference or variation of climate from the equator to the poles, in the tropical, the temperate, and the frigid regions of the earth; climates being hotter or colder according to their relative position from the equator to the poles. But the geographical latitude and difference of direction

in which the rays of the sun fall are not the only cause of the difference of temperature of climates; for the rays of heat, like the rays of light, sustain a greater or a less degree of reflection, according to the rare or dense medium of air which they pass through; that is, they are thrown back or reflected from the surface of the earth, and are more or less confined among the watery vapours with which the atmosphere is always loaded, in proportion to the density or rarity of the atmosphere. The vicinity of the sea has also considerable effect in moderating the temperature of places; for which reason the interior of continents is colder than the sea-coasts. Local causes and circumstances also have a considerable influence in producing variations of temperature of climate. Thus Germany and the cultivated parts of North America have been gradually increasing in temperature, as the forests have been cleared, the lakes drained, and the fens and marshes dried up. Even the climate of England itself has received a great improvement in temperature from the clearing and cultivation of the soil, and to this cause is assignable its amelioration of seasons within the period of only the last fifty years. The elevation of countries above the level of the sea has also a great influence on their temperature. Thus the whole elevated region of South America is of much greater genial temperature, that is, it has a lower degree of heat than the same latitude of the eastern portion of the earth. In that part of the globe the contrast of temperature in places even in immediate proximity is very marked.

Has the temperature of the earth been always the same from the creation of the terrestrial globe to the present time?—Geologists are of opinion, that the earth had a greater surface temperature during the deposition of the stratified beds of which the terrestrial globe consists than it has at the present

moment; and they account for its decreased temperature by its orbit having for ages become less elliptical, and consequently the inner axis increasing in the same degree. Another assumption is that the proportions of land and water at or near the poles have varied in the lapse of ages. The higher the polar land extends the greater of course would be the cold, and in proportion to the quantity of land at or near the equator would be the quantity of water at the poles. When, therefore, the water abounds at the poles, the temperature of the earth will be higher than when high land is present, and the more equally will that temperature be diffused. The occurrence of ancient ferns in Van Diemen's Land, in 42° south latitude, which is a much higher latitude than they reach in the northern hemisphere, seems to favour this hypothesis. The alternation of the relative positions of land and water at the equator and the poles is explanatory of the existence of tropical plants and animals under any latitude.

WHAT would be the result of a uniformity of temperature of climate?—A want of diversity of animal and vegetable nature, and as air throughout the world would have the same degree of elevation, density, and elasticity, there would be no wind, and consequently the air would become loaded with impurity, and the most disastrous consequences would ensue.

WHY is the heat of valleys greater than that of the summits and other parts of the elevations of mountains?—BECAUSE valleys are heated by the radiations from the sides of adjacent hills, the presence of forests, and being sheltered from the effects of winds and other causes.

WHY does elevation above the level of the sea produce the temperature of a genial climate in places which from their situation in the torrid zone would otherwise be parched up by

a tropical or burning sun?—BECAUSE the heat of the sun extends in its potent influence only to the surface of the earth; a regular gradation of temperature from the surface of the earth to the upper regions of the air taking place; the heat diminishing every hundred and twenty yards of ascent, as much as if an advance of one degree of latitude was made towards the north or south poles. It is for this reason, that in the elevated regions or table-lands of the torrid zone all the variations of climate are to be found that occur in either of the two hemispheres.

WHY is not the earth parched up by the accumulation of the continual absorption of the sun's rays?—BECAUSE, when the earth has absorbed a certain quantity of heat, it distributes it forth again into the circumambient air by the process of evaporation from the sea, lakes, rivers, and the surface of all water.

WHY, if heat is reflected from the surface of the earth, does it not increase or accumulate to so great a degree as to become insupportable and unfriendly to animal and vegetable life?—BECAUSE some soils absorb heat or the sun's rays in a considerable quantity. Thus moist, clayey, soft, dark, earthy soils absorb or take up and retain the heat or sun's rays until evaporated by the night air.

WHY is the heat in the sandy deserts of Africa of a scorching nature?—BECAUSE a dry sandy surface does not allow the absorption of the rays of heat, but immediately reflects them.

WHY is England not subject to the severity of heat and cold that is felt in similar latitudes?—BECAUSE of its insular situation, and the long continuance of the westerly winds, which bring copious moisture from the expanse of the Atlantic.

WHY are places in the vicinity of seas and lakes warmer in winter and cooler in summer than inland places are?—BECAUSE

the temperature of the strata of the air lying over the water is less subject to changes than that which lies over land. Though in winter the different layers or strata of the water lose a degree of their heat in their descent, yet each layer or stratum warms the atmosphere in the proportion of one degree more than five hundred times its bulk of air, and thus greatly tempers the atmosphere passing over it.

WHY are sea-coasts warmer than the interior of countries?—BECAUSE great expanses of the sea have a considerable effect in equalising and moderating the temperature of places and countries in their vicinity. It is for this reason that great continents have a contrary effect to great expanses of sea on the temperature of places in their vicinity.

WHY, as Moscow and Edinburgh are situate very nearly in the same latitude, is there neither extreme cold nor excessive heat in the latter city, while in the former the cold in winter is sometimes so intense as to freeze quicksilver, and there are often days in summer as hot as at Naples?—BECAUSE wherever there is a great expanse of water, as the sea, there is always a more uniform temperature in the adjoining countries throughout the year—less extremes of heat and cold. On the contrary, extensive tracts of land are liable to considerable vicissitudes; and for this reason is the difference of an insular and a continental climate in the same parallel of latitude.

WHY is the climate of Quebec, in Lower Canada, though lying in the same parallel of latitude as Paris, cold and unfriendly to health, while that of Paris is mild and genial?—BECAUSE the warmth or coldness of climate does not depend on its latitude or distance from the equator, but on its height above the level of the sea, the quality of the soil, the prevailing winds, and the nature of the regions which those winds have

previously traversed, in conjunction with other causes, both natural and artificial. Thus, in Europe, the prevalence of the south-west winds is one cause of the superior genial warmth that we enjoy; and the comparatively low temperature of North America seems to be occasioned by the cold winds from the north-west, by the great exhalations from the swamps, and by the immense forests, which prevent the sun's rays from acting on the ground. It is for these reasons, in conjunction with other causes, natural and artificial, that America and Asia are much colder in the same parallels of latitude than Europe is; and that plants in Europe bear the cold ten degrees further north than they do in the two other great divisions of the globe. The hypotheses of philosophers—even men of consummate talent—to account for the apparently anomalous occurrence of natural causes, are often extraordinary. Halley was of opinion, that the difference of climate of places lying in the same parallels in North America and Europe was occasioned by the tail of a comet striking the earth, and thus changing the position of the axis of its rotation, whereby the North Pole, which originally was very near Hudson's Bay, assumed a more easterly position; and Sir Isaac Newton supposed the design of the tails of comets was to replenish the exhaustion which the soil of the heavenly bodies sustained from the production of vegetation.

WHY does the climate of Quito, which lies almost under the equator, differ but little in temperature from the climate of Paris?—BECAUSE of its great height above the level of the sea —it being above 9554 feet of greater elevation than Paris. It is for the same reason—namely, their being composed of table lands at a considerable elevation above the level of the sea, that those parts of South America which lie under the equinoctial line are comparatively as temperate as the medium latitudes

of Europe; while the correspondent latitudes of the tropical regions of Asia and Africa are hot and unhealthy. It is to the same cause, also, that in Affghanistan (which has an elevated position of about 6000 feet above the level of the sea) the cold in winter is extreme. The oppressive heat predominating in the mountain defiles of that region during the summer season is occasioned by the reflection of the heat from the sides of the mountains.

WHY, though Madeira and the Bermudas are situated in the same parallel of latitude, is the heat of the summer in the latter island almost insupportable, (being often greater and more oppressive than that of the West Indies,) while the same season is deliciously cool and refreshing in Madeira?—BECAUSE the interior of the Bermudas is lower than the surrounding sea.

WHY are the deserts of Africa destitute of springs and rivers?—BECAUSE they have no woods or forests. The Cape de Verde islands, which were once well watered by springs and rivulets, and covered with magnificent woods and rich herbage, present only a sterile soil, covered with stunted bushes, and dry and parched up channels: a change produced by the removal of its forests.

WHY do the islands of the Atlantic, as Madeira, the Canaries, St. Helena, &c. enjoy a moderate climate, while the centre of the African continent parallel to them is nearly uninhabitable from its burning heat?—BECAUSE they are surrounded by a body of water, which is cooler than the land, and thus their temperature is reduced. This difference prevails in all islands and all tracts of land situated within the tropics; and to the same cause is attributable the difference of temperature of an insular and a continental climate lying in the same parallel of latitude in any part of the terrestrial globe. The

reason that the winter in Holland, under 52° lat., is severer than that of the Danish islands, lying under the 58th parallel, is owing to the exhalations arising from the moistness of the Dutch soil.

WHY is the temperature of islands which lie in the regions towards the poles higher than that of the continents to which they are adjacent?—BECAUSE the temperature of islands is raised in consequence of the atmosphere of the surrounding seas being warmer than the land under the same latitude. It is for this reason that England has a higher mean temperature than the parts of the adjoining continent of Europe under the same latitude, as Denmark, Sweden, and North Germany; and it is for the same reason, that the winter months are much less severe at Plymouth than they are at Paris, though the mean heat of the year is rather less at Plymouth than it is at Paris.

WHY is the temperature of the ocean more equable than that of the land?—BECAUSE of the continual upward and downward motions of its particles, caused by the changes of heat at its surface, and the constant or periodical movement of its waters.

WHY is the temperature of the northern hemisphere greater than that of the southern hemisphere; and why does ice occur sooner in the antarctic circle than in the arctic circle?—BECAUSE the sun is eight days longer on the northern side of the equator than it is on the southern side. Thus an impenetrable ice occurs at 70° of latitude towards the South Pole, while it is not found in less than 80° towards the North Pole. For the same reason, the heat in summer is greater in the northern than it is in the southern hemisphere.

WHY are the winds that blow from the south colder in New

South Wales and New Holland than those are which blow from the north?—BECAUSE as the accumulations of ice and snow occur at those places sooner than they do at corresponding latitudes in the north, the winds must consequently be the colder.

WHY are snow and ice found at a much less elevation in temperate climates, as on the summits of the Alps and the Pyrenees, at one time than at another, than within the tropics, where the line of congelation varies according to the season of the year?—BECAUSE in temperate climes there is a great variation of heat and cold; whereas within the tropics the heat of the climate is much the same during the whole year.

*** In every country there is a point of altitude at which water freezes both in summer and winter, and snow lies there constantly unmelted on the sides and summits of mountains. This point, called *the snow-line* or *line of congelation*, is in Europe at the height of from 5000 to 6000 feet above the level of the sea; in the tropical regions of Africa and America it is about 14,000 feet above that level.

WHY does eternal snow remain on the summits of lofty mountains within the tropics, and why is the line of congelation nearly at the same height all the year round?—BECAUSE the summits are above the line of congelation, and the higher the advance is made into the atmosphere the cold is proportionately greater.

WHY does the greatest heat prevail at and near the equator? —BECAUSE the rays of the sun are reflected or dart down there in their greatest degree of directness.

WHY in parts of the earth adjacent to the north and the south poles does the greatest degree of cold prevail?—BE-

CAUSE the rays of the sun are transmitted there so slantingly as to have little power.

WHAT occasions the periodical or tropical rains?—DURING the half-yearly visits which the sun pays in succession to the torrid regions on the north and south of the line, the air, heated by his presence, becoming rarefied, ascends, when the place it occupied is immediately filled by the circumambient air; and this process being constantly repeated, a constant rush of air, or, as it is technically termed, a *trade-wind*, is generated, which, being also influenced by the diurnal motion of the sun, is continuously flowing towards the equator. The air thus rushing towards the sun is by heat made capable of absorbing a greater quantity of water than it could obtain in a colder region, and therefore, as soon as the air and vapour united rise into high and consequently freezing regions, a separation between the two elements takes place, the air losing its power of retaining the vapour, which being immediately condensed becomes water, and falls down in what are termed *the tropical rains*, over a belt of country extending 1100 miles on each side of the line.

How are the trade-winds or monsoons, which extend thirty degrees on each side of the equator, occasioned?—BY the rarefaction and ascent of the air lying in the torrid zone, by the vertical influence of the solar rays, and the colder air from the temperate zone and polar regions rushing in to supply its place. During the summer of the northern hemisphere, the countries of Arabia, Persia, India, and China, are much heated, and reflect great quantities of the sun's rays into the atmosphere, by which it becomes extremely rarefied, and the equilibrium being thus destroyed, the air from the equatorial southern regions, as well as from the colder northern regions, flows or rushes in to

supply the vacuum produced by the ascent of the rarefied air into the higher regions of the atmosphere.

How are sea and land breezes produced, and what is the cause of their alternation?—THE sea breeze which prevails during the day is occasioned by the strata of the air of the earth becoming more heated by the rays of the sun than that over the surface of the sea; because the earth from its greater density, comparative state of rest, and numerous elevations, reflects the sun's rays sooner, and with more power, than they are reflected by the sea, which from its state of constant motion and transparency imbibes the warmth more slowly. Accordingly, when the rarefied air of the land rises into the higher regions of the atmosphere, the denser air over the surface of the sea rushing in to supply its place, produces the current of air called the *sea breeze*. On the other hand, when the sun sinks below the horizon, the body of air over the surface of the land becoming rapidly cold, and thus of lower temperature than the sea air, rushes in to supply its place, and thus the current of air from the land to the sea, called the *land breeze*, is produced.

WHY does rain fall abundantly in the latitudes adjoining to those where the trade winds predominate, while it seldom occurs in the region of the trade winds?—BECAUSE of the sudden mixture of the air of different temperatures charged with moisture.

WHY does rain seldom occur in the equatorial regions or those of the trade winds?—BECAUSE the constant circulation or intermixture of the air in those regions maintains so equal a temperature as not to occasion that condensation of vapour which is necessary for the production of rain.

WHY are the south sides of hills and mountains peculiarly fertile?—BECAUSE the solar rays strike their sides perpendicu-

larly, provided that the hills or mountains have a certain inclination on their southerly aspects, and the sun's heat a corresponding altitude. The reverberation of the light also promotes the fertility in such cases. It is for this reason, that in the Vallais, the Alps on one side are adorned with rich vineyards and orchards, and all the charms of fertility, while the opposite hills are covered with eternal ice, the ground there lying to the north, and receiving none of the sun's rays.

HYDROLOGY.

HYDROLOGY (derived from the two Greek words ὑδωρ, water, and λογος, description) is that science which explains the nature of water, its constituents, and properties.

WHAT is water?—A transparent fluid composed of hydrogen, one of the most inflammable gases known, and oxygen, the prime supporter of animal and vegetable life and of combustion. Pure water is composed of 88.9 parts of oxygen and 11.1 parts of hydrogen; or its composition by volume or weight is, by weight, one part of the first-mentioned constituent and seven and a half parts of the last; and in bulk or volume, two parts of hydrogen and one of oxygen.

OF what use is water in the economy of Nature?—IT prevents the change of the structure and gravity of the earth.

WHAT benefits result from the vast expanse of the ocean or the great space of the superficies of the globe which it covers?

—THE due irrigation of the earth from the moisture evaporated from its surface. Were the proportion of the surface of the sea diminished and occupied by land, the earth would, in the same proportion, become as a desert dry and sterile, from the want of its being properly irrigated. The water of the seas, rivers, &c. is of the same use, and performs the function as blood to the animal machine, carrying heat from the equator to the temperate zones, and receiving from the temperate regions the elements of cold which the currents that float from the poles impart.

WHAT occasions the impurity of rain water collected on buildings?—THE sulphate of lime and the carbonate of lime it has acquired from the roofs, bricks, and plaster of buildings.

WHAT occasions the comparative purity of snow and ice waters?—THEIR freedom from gas, air, or saline particles, which had been expelled during their freezing.

WHY is water fluid?—BECAUSE the particles of which it is composed are separated by caloric, or the principle of heat, as also by the particles of air intervening between them. The rationale and modus operandi why water runs or flows are inexplicable: see HYDROSTATICS.

WHY does water freeze or become ice?—BECAUSE it loses its caloric or principle of heat by the agency of cold.

WHY does water freeze first at its surface?—BECAUSE its surface first loses its caloric or principle of heat.

WHY does not running water freeze as readily as stagnant water?—BECAUSE the continual change of its aqueous particles prevents them from taking the cubic form, which is necessary to enable them to become congealed.

WHAT occasions the saltness or saline property of sea-water?

—THE saltness of sea-water is occasioned by the saline particles which rivers wash away from the different soils through which they pass, and carry into it, and which are also extracted from the salt rocks, or the extensive beds of salt at its bottom, as also from the decomposition of the animal and vegetable matter that is continually putrefying in it.

WHAT occasions the difference of saline matter in different seas?—CLIMATE and the maximum and minimum extent of evaporation.

WHY is river water not salt?—BECAUSE it has lost the saline property or the particles of salt contained in the water which has been vaporized off the land or sea, the saline particles with which it was impregnated having been too heavy for the sun to vaporize.

WHY will not sea water freeze at the same temperature as fresh water, but first requires the temperature to be more than four degrees colder?—BECAUSE it requires the performance of two operations to produce that effect; whereas in fresh water only one is necessary. Fresh water requires only to be simply frozen; but the saline particles have first to be separated from sea water.

WHY does ice float on water?—BECAUSE it is lighter than the bulk of the water from which it was congealed. It is on account of its buoyancy that the singular spectacle in some of the great American rivers occurs of large masses of stone encompassed by ice being seen floating down the stream, the buoyancy of the ice collected round the stone exceeding the weight of the stone.

WHY is ice lighter than water?—BECAUSE of the air-bubbles produced in the ice while freezing.

WHY does ice occupy a larger space than water?—BECAUSE the particles of water of which it is composed have become more expanded by the inclusion of the air which insinuated itself among them while in the act of freezing; consequently, the ice occupies a larger space than the water did from which it was formed. It is on account of this expansion that water freezing in pipes or vessels bursts them.

WHY is not rain that falls at sea salt?—BECAUSE the saline particles with which the sea water is impregnated being heavier than the water, the sun has not power to vaporize them.

WHAT are the constituent parts of sea water?—BESIDES pure water, the chief extraneous substances are muriatic or marine acid, vitriolic or sulphuric acid, fixed mineral alkali or salt, magnesian and sulphated lime.

WHAT is the proportion of saline matter in the water of the ocean to the water?—IT varies according to the distance from the equator, gradually decreasing as approaches are made towards the poles. The average proportion is about a twenty-eighth part, the specimens taken in different latitudes having varied from 3 to 4½ per cent. In the neighbourhood of the British Channel, the salt is said to be one thirty-eighth part of the weight of the water. Sea-water in certain places has been found less salt and bitter at the surface than at the bottom. Spurrman, who took up a bottle of sea-water from the depth of sixty fathoms, found it to taste like fresh water in which common salt had been dissolved.

How is the bright tremulous reflection or momentary display of gleams of the waters of lakes and ponds, when ruffled by a breeze, occasioned?—BY the reflection of the light of the sun or of the moon from the surface of each little wave or ripple.

WHY does the sea, when agitated at night, appear luminous or phosphorescent?—BY the presence of microscopic animals, particularly Infusores, gelatinous Molluscæ, or microscopic shrimps and animalcules.

WHAT produces the deepish green blue of the water of the sea?—IT proceeds from the same cause as the color of the sky, the blue rays being reflected in the greatest quantity on account of their superior refrangibility. The other colors assumed by the sea are accidental, being reflected from the color of the clouds by the presence of various substances and animalcules.

WHY does the water of the sea, when viewed where it has considerable depth, appear of a peculiar shade of green color, but when a portion of it is viewed in a glass, it appears perfectly colorless? — BECAUSE the quantity contained in the glass reflects or transmits to the eye too small a proportion of the color, or too faintly to produce a perception of the natural color of the water; whereas the great mass of water viewed at a considerable depth of the sea throws up its natural color in such abundance as to produce a strong and decided perception of it.

WHY do not the waters of the ocean, since they partake of the sphericity or convexity of the earth, run off the land?—BECAUSE they are retained in their place by the pressure of gravitation or the force of attraction.

WHAT produces the variety of colors seen in different seas and different parts of the ocean?—THE presence of foreign organic or inorganic substances. On this subject much interesting information is to be found in *Terrestrial Mechanism, or the Wonders of Geology Displayed*, division "The Wonders of the Ocean."

WHY are the Red Sea, the Yellow Sea, the Black Sea, the White Sea, &c. &c. so called?—BECAUSE of the color peculiar to their waters.

How is that difference of color occasioned?—BY the infusion of certain earthy or mineral substances occurring at their bottoms, or by the presence of multitudes of certain insects or animalcules in their waters.

How is the saltness of the Caspian Sea, and of the lakes of Aral, Baikul, &c. which are posited in an inland situation, as also those of Cuba and St. Domingo, occasioned?—BY the water being impregnated by the salt-springs, which are numerous in their neighbourhood. Salt lakes have been in general formed by the seas having thrown up narrow bars of sand during violent storms, and those bars have increased in extent in the revolution of ages, until the positions of the lakes have become considerably inland. The salt deserts on the shores of the Caspian have been formed by the gradual subsiding of its waters.

WHY is the surface of some closed seas more elevated and others lower than the general level of the sea?—THE greater elevation of some closed seas is produced because the mass of waters poured into them by the rivers which discharge themselves into their bosom is greater than that which is lost by evaporation, and the straits by which they are united to the ocean are not spacious enough to carry off with sufficient rapidity the surplus waters. The lower elevation of some closed seas is produced because the evaporation of their waters is greater than the supply from the rivers which run into them. For these reasons the level of the waters of the Baltic is higher than that of the North Sea, and that of the Black Sea is higher than that of the Mediterranean. The reason that the level of

the waters of inland seas (as those of the Black Sea, &c.) is higher in winter than in summer is, that the evaporation is less in cold than in hot seasons.

WHAT occasions that constant and incessant motion called THE TIDES, or the flux and reflux of the sea?—THE joint attraction of the sun and moon.

WHY are the tides, or the periodical flux and reflux of the sea, of use in the mechanism of Nature?—BY the incessant motion and the perpetual agitation in which the waters of the deep are kept, even in their most tranquil state, by the tides, the sea is not only prevented from being corrupted and putrified, but becomes a source of vitality to the whole animate and inanimate creation.

How are two tides produced on exactly opposite portions of the globe at the same time?—THE moon, by its attractive influence drawing the earth after it, or out of its natural relative position, draws up the waters into huge waves or protuberances on opposite sides of the globe, the wave or protuberance on the side opposite to the immediate action of the moon being produced by the land of which the earth is composed being drawn away from the water, and causing its greater elevation on the opposite side.

WHY do not the flow and ebb of the tide, or the periods of high and low water, happen exactly at the time when the moon is on the superior and inferior meridians, or when she is at her greatest distance from the earth or the nearest to it?—BECAUSE they are occasioned not only by the obstacles produced by the wind and particular local situations, but also by the friction on the coasts and on the bottom of the sea, and the tenacity and adherence of the particles of the water.

WHY in small seas are the tides but of small elevation or scarcely perceptible? — BECAUSE they are affected by the moon's attraction only in a small degree. The cause of the imperceptibility of the tides in some small seas is also occasioned by their waters being discharged by an under or concealed current, as is the case in the Strait of Gibraltar, the Sound, and the Channel of Constantinople.

WHAT occasions the variation of the height of the tides at different places?—THE direction and form of the coasts of countries, together with other varying causes of situations.

WHY do the highest tides on the coast of England occur in the Severn?—BECAUSE, as the mouth of the Bristol Channel is very wide, and opens to the south-west, so as to receive the tide-wave from the Atlantic Ocean, but the channel becoming narrower by degrees, and near Chepstow being very much contracted, the water is therefore heaped up at the upper end of the channel much above the level to which it would otherwise rise, and thus the tide-wave comes into the Severn in one large ridge, and consequently greatly elevates the water.

WHAT occasions the oscillations or waves of the sea?—THE water of the sea being put into motion by the influence or impulse of the winds upon the water, and its attempt to recover its equilibrium. This communicated force occasions a series of undulations to the surface of the liquid mass; motions which take place in conformity with the motions of the pendulum. The transmitted force does not alter the vertical position of the water, or produce any progressive motion on it; it merely affects its lateral position at given points. In storms, the effect is further produced by the currents of air or wind dislodging a portion of the waters, and thereby further destroy-

ing the equilibrium which they with equal force are endeavouring to regain.

WHAT occasions the variety of directions and figures in the waves of the sea?—THE force and directions of the winds, contending currents, and other causes.

WHY do the waves and the billows of the sea appear at times at noon of a silvery lustre?—BECAUSE the rays of the sun are reflected back from the surface of the water in their original purity and beauty, having not been refracted or diverted out of their course to the earth by an atmosphere of varying density.

WHY do the waves of the sea and the line of the visible horizon appear of a fiery glow when the sun is setting?—BECAUSE the rays of the sun fall obliquely on the expanse of the ocean, being refracted by passing through a dense atmosphere, and red being the least refrangible of the primary rays.

WHY does pouring oil on sea-water tend to mitigate the violence of the winds?—BECAUSE it tends to diminish the friction of the waves on each other, and to take off the agitation of their surfaces, by preventing them from curling or breaking.

WHY is the ocean of more equal temperature throughout the terraqueous globe than that portion of the earth which constitutes land is?—BECAUSE it is less easily heated by the sun's rays, and partly because of the constant mingling of its waters by the currents and the motion of the waves.

WHY are the waters of the sea not warmed to any considerable depth by the intensity of the sun's rays?—BECAUSE water is a bad conductor of heat, and therefore if water is heated on its upper surface, whether by the action of fire or the sun's rays, heat penetrates with difficulty, and requires a

length of time before it can reach the lower strata of the liquid.

WHY is sea air warmer than land air?—BECAUSE water is a denser body and a worse conductor of heat than land is, and therefore it retains temperature for a greater length of time than land does.

WHY when the land-air is hot are the sea-breezes cool and refreshing?—BECAUSE the continual motion of the waves presents a fresh surface to the heated air, which falls upon the surface of the water, and consequently cools it; so that when the heated land-air rises up into the upper regions of the atmosphere, the cool sea-breeze springs up, and rushes in to supply its place.

WHAT produces the currents of the sea?—TEMPERATURE, winds, peculiar constructions of coasts and inlets, together with the primary cause, the rotation of the earth.

WHAT occasions the constant current of water that sets in from east to west between the tropics in the open ocean?—THE constant circulation or revolving motion of the waters, called *the Gulf Stream.*

WHAT occasions the tropical rains that cause the rising and flowing of the river Nile?—WHEN the sun, to adopt the vivid language of Herodotus, pays his regular visits to the torrid zones on each side of the equator, the air becomes so heated by his presence as to expand and fly upwards; the vacuum thus created is immediately filled by the more distant and colder atmosphere, which, in its turn, becomes rarefied, and is again in like manner replaced. A constant rush of air is thus maintained, which is commonly termed the *trade-wind.* This being also influenced by the sun (or more strictly by the earth) is for ever flowing towards the equator. The rarefied air in the

neighbourhood of the sun is capable of absorbing a greater portion of water than the cold air can contain; but when it has ascended to a higher and a colder atmosphere, its loses its power to retain the denser vapour, which accordingly descends to the earth in the shape of tropical rains.

How are rivers produced?—From springs which are fed by the means of vapour carried off from the surface of the sea or of rivers, &c., the ridges of hills and mountains.

Why do the currents of some rivers pursue a straight course, and those of others a winding or serpentine course?—The straight course is occasioned by the velocity of the current, and no impediment being presented to it; and the winding or serpentine course is produced by the slowness of the current, the inequality of the ground, or the meeting with obstacles or impediments, or by a combination of two or all of these causes.

What occasions an under and an upper current in some rivers; that is, why does the surface of the water move in one direction, while the water at the bottom is flowing in an opposite direction?—The action of the tides, and the difference of specific gravity between salt and fresh water. This phenomenon is thus produced. When the tide is flowing onwards the salt water rushes up the channel of the river, while the current of fresh water being lighter floats on the top, and pursues its downward course towards the sea.

Why do currents of rivers flow with different velocities; and why do they flow slower at and near the bottom than at the surface, and at the sides than in the middle?—Because of the greater or less effects of friction, arising from the inequality of their banks, the angles, bends, or sinuosities in the course of their streams, the roughness and inclination of their beds, or

the greater or less supply of water at their sources, or which they derive in their course from other streams. They flow slower at their sides and bottom than in their middle and surface, because of the friction and obstruction to which they are liable there.

WHY are the banks of rivers which have a very gradual descent seldom injured by the action of floods?—BECAUSE such a construction allows a full and open channel to the current, and a flood or torrent spends its violence comparatively harmlessly on the shelving or sloping bank to what it does on a perpendicular one.

WHAT occasions the diminution of the waters of rivers?—THE cutting down of forests on the mountains in which they rise, and thus the attraction of the vapours of the clouds, and consequently the quantity of rain on which the supply of rivers depends, is diminished. Instances of this effect occurred on a large scale in Kentucky and New Jersey. On the other hand, the cutting down of forests in level countries increases the volume of water in rivers.

WHAT occasions the phenomenon of the stoppage of the course of rivers, as that of the Teviot, Clyde, and Nith, Nov. 17, 1838?—THE formation of fissures, or, as geologists term them, slips, under or across the channels of the rivers into which the waters discharge themselves. The return of the waters to their usual channel is produced by the closing up of the fissure by the sediment carried into it by the water.

How are subterraneous rivers formed?—BY volcanic action. Thus in the great earthquake which happened in the plains of Jorullo, in Mexico, in the year 1759, the rivers of San Pedro and Castamba, in the night of 10th September of that year,

reappeared 6560 feet further west, in the volcanic ground formed by the eruption.

WHY are waters of rivers of various colors? — BECAUSE they run over earths and rocks partaking of their colors. Thus the Rhine in its course from the Alps to the Lake of Constance is bluish; after its passage through the green waters of that lake, it is grass green; and after repeated mixtures with the rivers and streams of Alsace and the Black Forest, it is yellowish green. The Maine, flowing from the ferruginous rocks and plains of Franconia, acquires a reddish yellow color; during great degrees of cold it becomes greenish blue, owing to the deposition of the iron ochre; sometimes it partakes of a yellow color, and sometimes of an amber grey. The rivers of Bavaria, which are formed of waters from lakes, are bluish green in winter, grass green in spring, and herb green in autumn. In the sunshine the Ganges has a sparkling appearance too dazzling for human gaze, and in the course of the day assumes appearances no less beautiful. It is first of a saffron color, then of the hue of the rose, and lastly it appears like polished steel studded with ingots of gold.

WHY when rivers are frozen over are they not cemented into solid masses of ice?—BECAUSE the ice formed on the surface of the water (which is a bad conductor of heat) prevents the evolution of the latent heat or caloric of the water which is below the ice.

How are lakes produced?—THEY are formed by the sands of the sea pushing pools of water before them in their passage from the sea-shore.

WHAT occasions whirlpools?—THE meeting or contact on a centre or narrow passage of two currents of equal force, but of

different directions, which whirling round each other produce an eddy, that is augmented according to the force of contending tides or of the action of the winds.

*** The three most noted whirlpools are, Euripides, on the coast of Greece; Charybdis, in the straits of Sicily; and Maelstroem, on the coast of Norway. The first absorbs and rejects the water seven times in every twenty-four hours, the second three, and the third four times.

How are water-spouts and storm-pillars produced?—Two explanations are given of these phenomena. The first is, by the action of atmospheric currents, which are produced by the meeting of two winds, when any cloud which happens to be between them is condensed into a conical form, and being turned round with great velocity, all the particles constituting the cloud are driven from its centre, when the water lying beneath rises by its inherent principle into the vacuum, and thus produces the water-spout or storm-pillar. The second is, that they are a species of whirlwind, produced by the collision of contending winds or of atmospheric currents running in opposite directions in the higher regions of the air. Water-spouts and storm-pillars are often half-a-mile high and 100 to 120 yards in diameter at the base. Their formation is generally thus: below a heavy cloud, an ascending column of water of a conical form, resembling a trumpet, is observed, and vertically above this ascending column, a corresponding cone is formed in the air, but in an inverted position, which gradually approaches the water cone. The ascending and descending columns form a junction, not exceeding two or three feet in diameter. These water-columns occur occasionally above land. In 1718, one was seen in Lancashire. Both by sea and land they are destructive; at sea, often sinking small vessels upon which

they fall; and they overturn trees, buildings, &c. No reasonable solution can be given for the production of these phenomena, except that of the agency of electricity. They are accompanied with sulphureous smells and flashes of lightning.

*** These phenomena are termed *water-spouts* when they occur at sea; *storm-pillars* when at land. Tropical latitudes are the chief scene of the action of these atmospheric phenomena.

How are pools and lakes of fresh water produced in ice-fields and icebergs?—By the melting of the beds of snow, with which they are often covered from a foot to a fathom in depth.

Why is rain of a yellow and a red or crimson color?—Because it is impregnated with the red and yellow pollen or seed-dust of the flowers of pine, fir, beech, juniper, or other trees, which is carried by the action of the wind, and descends with the rain in the neighbourhood of the places where such colored rain has fallen. Red or crimson rain is also occasioned by an incorporation of a minute fungous vegetation or by a red matter fallen from insects and butterflies, or from having been mingled with an infinitude of animalcules, which have been picked up by a water-spout into the atmosphere, or which have been overtaken while carried along by the winds, and brought down by the falling drops. Viscid or glutinous rain is produced by an incorporation of animal and vegetable matter.

Why are snow and ice sometimes found to be of a pink or rose, or of a brown, red, green, blue, and yellow color?—Because those colors are produced by the same natural causes which produce red and yellow rain; they are, however, occasioned by the various colored earths with which snow and ice are impregnated. Captain Scoresby attributes the redness of

the snow which occasionally falls in the Arctic regions to the impregnations of the little awk, which accumulates in great numbers under the snow in those parts. These singular and anomalous appearances are also produced by plants of atmospheric growth, and of infinitesimal size or minuteness. Red snow is very common in all the Alpine districts of Europe as well as in the Arctic regions. The most remarkable red snow-shower in recent times was that which fell on the night between the 14th and 15th of March, 1823, in Calabria, Tuscany, and the whole chain of the Apennines. Fabroni (Ann. de Chim. tom. 83) mentions one which happened near Arezzo, in March, 1813, which continued to fall for many hours. Both snow and ice stained with red, green, and blue, were seen by the late expedition under Baron Wrangel to the Frozen Ocean; and Humboldt says that red hail has been seen to fall at Paramo de Guanacos, on the road from Bagota to Popayan. Agardh, in an interesting memoir, mentions several of these supposed preternatural occurrences. Saussure saw, in 1760, red snow in abundance on Mounts Brevern and St. Bernard, in Switzerland, and frequently among the Alps. Ramind found it on the Pyrenees, and Sommerfeldt in Norway. In March, 1808, the whole country about Cadore, Belluno, and Feltre, was in a single night covered to the depth of twenty centimetres with a rose-colored snow; and at the same time a similar shower was witnessed on the mountains of Veltelin, Brescia, Krain, and the Tyrol.

How are showers of frogs, toads, fish, creeping reptiles, seeds, &c. produced?—By the agency of the wind. Not many years ago, during a strong gale, herrings and other small fish were carried from the Frith of Forth to Lochleven in Scotland,

which are ten miles distant from each other. A shower of toads is reported to have fallen many years ago at Portobello. In 1804, a shower of frogs took place about three leagues from Toulouse. (See Institut. 166.) The writer of this work, when a boy, witnessed a shower of tadpoles during a heavy storm of rain at Walworth, in Surrey. It is recorded in the history of Norway, that a shower of rats fell in one of the valleys of that country, having been intercepted by the wind in one of their migrations from the high to the low countries. The harbour of Christiansoe was once swept out so fully by a storm-pillar, that much of its bottom lay bare. During the eruption of volcanoes the ashes and scoriæ have been carried a prodigious distance.

WHY do circumnavigators in sailing round the globe in a westward direction experience the loss of a whole day and night in their reckoning of time (for instance, having entered in their diary on their arrival at the port from which they set sail, Monday, when in fact it was Tuesday); and in sailing in an eastward direction, find on arriving at the port of their departure, that they have gained a whole day and night, for instance, that it was only Monday, when according to their reckoning it was Tuesday?—BECAUSE, in the first case, they have made one turn more round the centre of the globe, and in the second, one turn less than the persons have who were situated at the places of departure; a circumstance occasioned by all the days in the first case having been longer, and in the second case shorter than those of the place of their departure; for in proceeding in a westerly direction, they met the sun (which rises in the east and sets in the west) later; but when proceeding in an easterly direction, they met that luminary sooner than its rise took

place at the port of their departure, in the proportion of an hour for every fifteen degrees of their voyage.

WHY is the passage of ships from America to Europe (particularly to England) quicker than from Europe to America?—BECAUSE their passage is expedited by the north-west current, which sets in upon Europe from the coast of America. The effect of that current is also aided by the prevalent westerly winds.

How are the banks of fog which prevail in the atmosphere off the Bank of Newfoundland occasioned?—BY the vapours arising from the union of the cold current of water which sets in from the north towards Newfoundland, and of the tropical current of water or Gulf-Stream, which had been detained for a long time in its passage in the great hot gulf formed by the coast of the Caraccas and the Mexican and Floridan coasts, the temperature of the former having been ascertained to be 50° of Fah., while that of the latter was 72°.

WHAT occasions that constant circulation or revolving motion of the waters denominated *the Gulf Stream*?—THE evaporation caused by the heat of the sun in the neighbourhood of the tropics, and the counteracting movement occasioned by the rushing of the polar waters towards the equator to restore the equilibrium. The rush or flow of the surplus waters of the Gulf of Mexico adds also to its effect.

WHAT occasions the waters in the Gulf of Mexico to be of higher elevation than those of the Pacific and that part of the Atlantic Ocean that is conterminous with the Gulf of Mexico? —THE vast issue of fresh waters which pour into that Gulf, in conjunction with the current of the Atlantic which pours into the Caribbean Sea, and thence into the Gulf of Mexico.

WHY do ships in their departure from Europe to America,

instead of sailing direct across the Atlantic, first descend to the latitude of the Canary Isles?—To get into the tropical current or trade winds, which set in across the Atlantic, whereby ships are carried to the coast of America in a comparatively short space of time to that which would have been the case had they made a direct passage across the Atlantic. For the same reason, ships returning to Europe from the West Indies, sail to the coast of Newfoundland, in order to catch the western breeze that blows off that coast; and thus they are enabled to run down upon any desired point of the continent of Europe.

How have the great natural excavations or caverns found on the surface of the earth, such as that of the Mammoth Cave, in Kentucky, North America, and that near Blackenberg, in the Hartz Forest, in Germany; the first-mentioned of which has been explored to the distance of between nine and ten miles, and the second to that of twenty miles, without any boundary having been ascertained in any of their numerous windings, been produced?—By subterranean currents of water which have enlarged original fissures, or carried away masses of soft or loose sand that were interposed between layers of hard rock. Besides having been produced by the escape of infiltrated water, the subsidence of rocks, or the upheavement of them by earthquakes or volcanic agency, has also originated some caverns.

PNEUMATICS.

PNEUMATICS (from the Greek πνευμα, breath or air,) is that branch of natural philosophy which investigates the mechanical properties of air and the various aeriform or gaseous fluids, namely, their weight, equilibrium, density, elasticity, pressure, or motion.

WHY is heated air lighter than cold air?—BECAUSE its particles are more expanded than those of cold air.

WHY is the air warm in misty or rainy weather?—BECAUSE its latent heat having been liberated is diffused through the atmosphere.

WHY are ill-ventilated rooms unfriendly to health?—BECAUSE the air contained in them having lost its vital principle, has become vitiated.

WHY is the stratum of air at the bottom or on the floors of rooms, cellars, and other inclosed places, more unwholesome than the stratum which is at the top or ceiling?—BECAUSE it is surcharged with carbonic acid gas; as also the foreign substances which intermingle with the air, such as dust, &c. Another reason is, that the foulest portion of the air being the heaviest, naturally sinks below the purer air.

WHY does carbonic acid gas take its position in the lower stratum of the air?—BECAUSE it is the heaviest of the aerial fluids until rendered relatively lighter by combustion, when it ascends.

WHAT occasions the warmest air to take its position at the tops of rooms, and the coldest at the bottom?—BECAUSE air rarefied, being specifically the lightest, mounts above that

which not having become rarefied is denser, and it therefore retains a lower position in the atmosphere of a room.

WHY do the lower strata of the air contain less carbonic acid than the higher strata?—BECAUSE the lower strata being in contact with vegetation the carbonic acid is consumed by it.

WHY does carbonic acid abound more in temperate and cold climates than in tropical and warm climates?—BECAUSE the proportionate absence of vegetation in temperate and cold climates prevents the greater consumption which takes place in tropical and warm climates, on account of the profuse vegetation existing there.

How then is the excess of carbonic acid generated in the cold or rigid and the temperate regions removed?—BY the influence of the winds, which bring with the same stream of air that is put into motion by the revolution of the earth from the equator to the poles, the oxygen generated in the tropical regions, and which remove the carbonic acid generated during the winter in temperate and polar climes.

*** The quantity of carbonic acid gas generated is varied according to the time of the day, the period of the year, the age of the animal, the nature of the food consumed, &c. The maximum or largest quantity is generated or undergoes decomposition about noon; the minimum or smaller quantity at night. It is said in all educational works,—and the error is also to be found in many scientific and medical works,—that the greatest quantity of carbonic acid is generated during the night; an error that the least reflection might have obviated, had it been recollected that the vegetable like the animal creation is quiescent during that season.

WHY is the air of crowded apartments and theatres prejudicial to health?—BECAUSE if they are not properly ventilated,

the vital principle of the air, namely, the oxygen, is consumed by the breathing of the persons present; and where lights are used the danger is greatly increased, as carburetted hydrogen is engendered—a gas unfit for respiration as being highly destructive of life. The air of a theatre from the commencement to the end of a play has been found to have lost its oxygenetic or vital principle nearly one-fourth, or as 21 to 27, and is therefore in that proportion less fit for respiration. The deterioration takes place in proportion to the number of spectators, and the amount of the gas or other light consumed.

WHY is the air in the pit of a theatre or in the body of a church, or any large crowded room, purer and cooler than that in the boxes, the gallery, or upper part of the building?—BECAUSE that part of the air of which carbonic acid gas, &c., is formed by the animal breath or combustion of lights, being by the combustion of the lights rendered of less specific gravity than the other constituent parts of the air, ascends or rises to the upper part of the building, and leaves the atmosphere in the lower part of the building in a comparative state of purity. Of course the longer the continuance in the tainted air, the greater is the danger incurred.

WHY is air unfit for respiration when deteriorated by breathing, and after combustion of a body in it has taken place?—BECAUSE of the consumption of its vital principle, the oxygen (the component part of atmospheric air essential to the maintenance of animal life), which has taken place, and the consequent generation of carbonic acid gas.

WHY is it dangerous to go immediately from a heated apartment, ball-room, theatre, or other crowded assembly, into a frigid nocturnal atmosphere, or to approach the fire immediately on coming from a cold air?—BECAUSE on account of the difference of temperature the delicate structure of the lungs is

exposed to the atmospherical transition from a hot to a cold air, which often varies from thirty to forty degrees; and by approaching a fire from a cold air, the blood, by the sudden change of temperature to which it is exposed, rushing with violence into the lungs and the glottis of the throat, which had been rendered torpid by the cold air abstracting their natural heat, an inflammation of those organs is often superinduced.

WHY is it dangerous to descend into a pit or cellar, or to enter a cellar or room, that has been long shut up, without previously ascertaining the state of the air?—BECAUSE of the presence of carbonic acid gas or fire damp, or, as the miners term it, the choke damp, which is eminently pernicious to animal life. To ascertain the state of the air in such places, a lighted candle should be let down into them, and should it become extinguished, a vessel containing quicklime should be lowered into them, and then water should be sprinkled or thrown slightly upon the lime before any person ventures to enter or descend the place; or Sir Humphrey Davy's safety lamp should be suspended in the place, which on account of the strong attraction of metals for heat and the consequent facility with which they abstract it from other bodies, will consume and extinguish the inflammable gas.

WHY is the air in the interior of extensive forests unwholesome?—BECAUSE the large quantity of carbonic acid gas which the trees, plants, and other parts of the vegetable creation emit, has not been absorbed by the atmosphere.

WHY will not a candle remain lighted in a cellar containing wine or malt liquor in a state of fermentation?—BECAUSE of the carbonic acid gas engendered by the exhalations of the wine or malt liquor, such gas not being calculated for the supply of fire or for the support of animal life.

WHY are marshes and stagnant waters unwholesome?—BECAUSE they undergo fermentation, and becoming corrupted, give rise to exhalations that produce the most pestilent diseases.

WHY is a fire-place the most insecure spot to be near in a room during a thunder-storm?—BECAUSE, when lightning strikes a house, it often falls on the chimneys, either from their being the most elevated parts, or because they are lined with soot, which is a better conductor than dry wood, stone, or brick. The iron or steel of which the stove is composed also lends its agency in the conducting of the electric fluid.

WHY is it more dangerous to stand under or near solitary trees than near a lightning rod during a thunder-storm?—BECAUSE trees do not convey the lightning with sufficient rapidity to the ground in order to its dispersion.

WHY are persons cloked in silk dresses when struck by lightning not killed?—BECAUSE silk, both raw and dyed, being a non-conductor, serves to insulate or protect the body, and thus prevents the access of the electric matter.

WHY do balloons move with greater velocity than the winds do?—BECAUSE the air in the higher regions of the atmosphere has a more rapid motion than the air near the surface of the earth; besides a balloon having acquired in its ascent a great velocity, a considerable momentum is imparted thereby to its onward course; the velocity with which balloons have sometimes been transported through the air having amounted to eighty miles an hour.

WHY are balloons enabled to raise the weight of their apparatus and ascend into the air?—BECAUSE they are filled with an air of less specific gravity than atmospheric air.

WHY cannot balloons ascend higher in the air than about four miles?—BECAUSE the air at that height is more rarefied

than the gas contained in the balloon. It is for the same reason that birds when allowed to escape from a balloon at a great height, fall almost perpendicularly downwards, the attenuated state of the air not having sufficient inertia to offer resistance to their wings.

WHY is the continuance of balloons in the air limited?—BECAUSE of the constant liberations of the gas which are necessary to prevent the disruption or explosion of the balloon, and which are occasioned by its expansion in consequence of the removal of the atmospheric pressure in the course of the ascent of the balloon, and the discharge of the ballast in consequence of the absorption of moisture from the clouds.

WHY are flies able to run up a wall, perpendicular piece of glass, or on the ceiling of a room?—BECAUSE their feet are provided with cavities, the sides of which being adapted to the surface of the glass or of the ceiling, the cavities are, by some internal mechanism of the feet, exhausted of the air, and the pressure of the atmosphere on the minute surface of their feet counteracts the power of gravitation. The adhesion of snails, periwinkles, limpets, and some other crustaceous animals to rocks and stones is effected on the same principle. The surfaces of their shells at the opening are capable of being exactly fitted to any plane surface; and the animal has the power of producing a vacuum within its shell when thus fixed, and the atmosphere consequently presses upon it with a force proportioned to the exterior surface. On the same principle also the lacerta gecko, a species of lizard, walks up and down the smoothly polished walls of the Javanese houses; and the walrus, an amphibious marine animal, climbs the smooth surface of ice in the Arctic regions, and the shark and the fish called remora attach themselves to the sides of ships.

WHY, if the pressure of the atmosphere is so great (namely, on an average 14½ lbs. on every square inch of the earth's surface,) can so great a weight be supported by living animals, namely, 30,000 lbs. on the body of a middling sized man whose surface generally contains about 2000 square inches, without being sensible of it?—BECAUSE the elasticity or spring of the air which is in the human body reacts with an equal force to the pressure of the external air, and thus an equilibrium is created; that is, though the air presses with a downward pressure of 14½ lbs. on every square inch, its downward pressure is resisted by its upward and lateral pressure with an equal force.

*** The pressure of the atmosphere is equal to the weight of the column of air above the spot, and proportional to the density of the air at the place. Atmospheric pressure in ordinary conditions of the air, and at the level of the sea, is equal to 14.7 lbs. to the square inch; consequently in depths below the level of the sea the pressure is greater, and at heights above its level, less; in each case proportionately to the depth or height, and in each case the greatest density is at the surface; but this difference subsists between the depth and the height of air below or above the surface: it gradually increases downwards from the surface, but it gradually diminishes upwards in a geometrical ratio until it has no appreciable pressure. Persons in balloons have had their limbs swollen, and others on ascending high mountains have been unable to breathe on account of the extreme tenuity of the air.

WHY, since respiration is difficult and painful at the summits of mountains and in elevated regions, do the inhabitants of the plains of Mexico and Quito, which are respectively 7775 and 9554 feet above the level of the sea, experience no inconvenience from the rarity of the atmosphere?—BECAUSE, as the animal

frame adapts itself to the conditions and circumstances under which it may be placed, the chests of the inhabitants of the plains of Mexico and Quito, as well as of all other elevated situations, are larger than those of the dwellers in the lower regions; and, therefore, at each respiration they are enabled to receive a sufficient quantity of the rarefied air to oxygenise their blood.

WHY is respiration difficult and painful, and the distressing sensation of suffocation experienced, at the top of a mountain or in elevated regions?—BECAUSE the air in elevated regions being of less elasticity and pressure than the air within the body, persons ascending them are unable to draw in a necessary quantity or volume of air at each inspiration or movement of the lungs so as to be sufficient for the sustentation of the vital functions and as a counterpoise to the pressure of the external air. In such cases, however, were the transition to be gradual so as to allow time for the air within the body to acquire the same condition as the air without, it is probable that the painful and difficult respiration would not ensue.

WHY, when travellers in ascending a mountain arrive at a region where the surrounding air is much rarefied, do they experience painful sensations, fulness and throbbing of the temples, with the most distressing lassitude, and why does rupture of the more delicate bloodvessels in the eyes, mouth, and lungs sometimes takes place?—BECAUSE not only the air within the body, being denser and more elastic than the external air, opposes a greater or more unequal pressure than is met by any counterpoise of the external air, but a consequent expansion of the air and fluids contained in the body takes place, and the increased rarity of the air in such elevations demanding a more rapid respiration, in order that the necessary quantity of air

should traverse the lungs, the circulation of the blood is materially accelerated.

WHY is the atmospheric pressure less at the summits of mountains than at their base or in valleys?—BECAUSE the weight of air diminishes or becomes less dense in proportion to its distance from the surface of the earth and the level of the sea. The variation which is also found to take place in water, as also all bodies similarly placed, is occasioned by the same cause, namely, the diminution of the atmospheric mass, which decreases in weight or pressure according to its proportional vertical height or distance from the level of the sea.

WHAT occasions the unpleasant sensations, as lassitude, &c., which changes of the temperature of the weather produce in the animal system?—THE variations produced in the atmospheric pressure by the temperature of the weather.

WHY does change of climate produce its remarkable influence on the human constitution?—BECAUSE of the variability of atmospheric pressure in warm and cold climates and at different elevations of country, and of the alterations caused in that pressure by the expansion or lightening of the air by heat, and its increased density by cold and moisture.

WHY is air warmer on low than on high grounds?—BECAUSE of the difference of its density at the two places; the denser the air, the greater is its capacity of retaining warmth from the rays of the sun or any other source of heat. A further reason that the air on low grounds is warmer than that on high situations is, that the air from the superincumbent pressure is of a compacter substance, and contained in a comparatively smaller bulk, and therefore a greater quantity of heat is concentrated within its compass. It is for these reasons that in the warmer regions of the globe the air is cold on the tops of the highest mountains,

the air being there so rare or thin as to be incapable of forming a medium for the retention of the rays of the sun.

WHY is the air on the surface of the land of greater temperature than that on the surface of the sea?—BECAUSE of the greater density of the earth, its comparative state of rest, and numerous elevations; all which enable it to retain the heat imparted to it during the action of the sun for a longer period than the sea can.

WHY, during excessive heat or very damp and moist weather, do we feel indolent and uncomfortable?—BECAUSE, in the first case the air being rarefied by the heat, and in the second case being charged with humidity, it does not press upon our bodies with sufficient force to keep in equilibrio the air that is within us, which expanding occasions the lassitude that we feel in hot weather, and the uncomfortable sensation that we experience in very damp and moist weather. Or in other words, the elasticity of pressure of the air within the body does not correspond to the external aerial pressure; the uneasy sensations arising from the pressure of the external air being lighter (instead of being heavier, as is erroneously supposed) than the resistance of the internal air; and thus in both cases the animal fibre is relaxed, and its power reduced.

WHY is the excessive heat of summer oppressive?—BECAUSE, as air is not a good conductor of heat, the atmosphere does not allow the ready transmission of the accumulating heat of the body.

WHY do ships six or eight miles out at sea appear quite becalmed when a fresh sea breeze is blowing in upon the shore?—BECAUSE the progress of sea breezes proceeds gradually from the shore, the mass of air nearest the land being the first rarefied.

ACOUSTICS.

ACOUSTICS (from the Greek word *ακουω*, I hear) is that branch of natural philosophy which explains the nature of sounds, their production, propagation, and effects.

WHAT occasions sound?—THE vibrations or undulations of the air, which, originating in a centre point, pass spherically outwards in all directions, like the waves produced by the dropping of a stone in a pool of water.

WHY are sounds of greater audibility by night than by day? —BECAUSE the temperature in the atmosphere by night is of greater uniformity and transparency. Also the auditory nerves are more sensible to impressions, on account of the universal and dead silence then prevalent.

*** Sound transmitted or conducted by different bodies has different degrees of velocity. In air it travels at the rate of 1142 feet in a second, in sulphurous acid 731 feet, in hydrogen 3000 feet, in water 4708 feet; and in solids it has a much greater augmentation, passing through tin at the rate of 8175 feet, and through iron, glass, and some kinds of wood at the rate of 18,530 feet in a second.

WHY does spreading the hands on each side of the mouth occasion the sound of the voice to be heard more audibly and at a greater distance?—BECAUSE their position checks or diminishes the waste of sound by its lateral dispersion. It is on this principle that sound is conveyed through pipes, or by means of extensive flat surfaces, as walls, champaign countries, &c.

WHAT occasions echoes?—THE reflected impressions made by sound against opposing substances, as rocks, walls, &c.,

being thrown back by the configuration of the opposing obstacles at angles equal to the angles of incidence.

WHY does the discharge from a long line of musketry seem, to a person standing at a distance, and directly in the front, as a single collected crash or sound, but to another person stationed at the end of the line does it seem a prolonged rolling noise, resembling a running fire?—BECAUSE in the first case the individual reports all reach the ear nearly at the same instant, but in the second the distant sounds reach the ear in continued succession, according to the different distances they have travelled.

WHY is the same sound of different degrees of intensity at different times? — BECAUSE the variation in the transmission of sound depends on the state of the surrounding air, namely, on its density, the quantity of vapour suspended in it, and the clouds that extend above it. Thus, when the air is foggy its undulations are interrupted, and the sound is dull and prolonged; when it is overcharged with clouds its undulations return back, producing a succession of echoes; and when after nightfall the heat from the ground has been uniformly diffused, and the air is of an equal density, every sound is transmitted with peculiar intensity, whether we listen to the rippling of the distant stream, the buzzing of some minute insect, or the sound of distant sheep-bells, or nocturnal music.

WHY is sound proceeding in two opposite or different directions stronger than when proceeding in but one direction?—BECAUSE of the union of the sound, that is, the formation of the strength of the two sounds in one double one from the two centre spots.

How is echo, or the sound of the voice or that of an instrument, produced?—BY the reflection or repercussion of

the air from any resonant obstacle, such as hills, rocks, houses, clouds, trees, &c. partaking of irregularity or unevenness, when the vibrating waves of air rebound in a direction contrary to that of their former movement, and thus carry back the sound or form an echo to any ear which is within the range of the repercussion, the secondary motions reaching the ear later than the primary ones.

How are compound echoes, or the sound of the voice or that of an instrument, heard twice or oftener in certain places? —BECAUSE the position of the various obstacles against which the undulations of the air impinge is such that the separate reflections of sound caused by them strike the ear at different times, or the locality is such that the sound, once reflected, meets new obstacles, and is re-echoed for a greater or less number of times.

*** The most celebrated known echoes are,—1, that at Milan, which repeats the human voice about forty times, and the report of a pistol about sixty times; 2, that of Woodstock Park, in Oxfordshire, which repeats by day a syllable seventeen times in succession, and by night twenty. The other celebrated echoes are those at Thornborough Castle, Gloucestershire; Roseneath, near Glasgow; at Genesay, near Rouen; and at Stepney Church, in Sussex; at Brussels; at the Menai Bridge, in Wales; at Castle Comer, in Ireland; the Eagle's Nest, near Mucross Abbey, on the banks of the Lake Killarney; in the cemetery of the Abercorn family, at Paisley; on the Lake Ontario; and those in some of the West India islands, which are very beautiful and romantic.

WHY, when the reflection of sound impinges on a concave surface, or a building of an oval or an elliptical form, is the sound that proceeds from one of its foci reflected to the other,

so that two persons placed at the two foci may converse with each other, and the spectators hear not a word passing between them; and they may converse in the lowest tone of voice, and yet they will distinctly hear each other?—BECAUSE, in the first case, the sonorous undulations produced, striking against the hard or solid body of the building, are obstructed; and in the second case, the direct motion of sound being reflected at an angle to its incidence, and with a velocity proportioned to that wherewith it impinged against the solid, a secondary vibratory motion arises, increasing the primary one.

*** The construction of the whispering-galleries of St. Paul's and Gloucester Cathedrals, the Hall of Secrets in the Observatory at Paris, the baptistry of Pisa, and the cathedral of Girgenti in Sicily, and that of several other places, produces these effects. It is to the same principle that the "magic mirror" of conjurors is indebted for its effect.

WHY are music, the ringing of church-bells, the moaning of the sea, and other sounds frequently heard at a great distance preceding rain and storms, and more distinctly in damp or moist weather than in dry weather?—BECAUSE preceding rain and storms the air is generally denser than usual, and dense strata of atmospheric air reflect and convey sound more strongly, rapidly, and farther than rarified strata do. For the same reason that sound is conveyed better through a damp or moist than a dry medium, the odour of plants and flowers, as also smells of all kinds, are much more powerful in moist than in dry weather.

WHY, when the extremity of a log or beam of wood is slightly tapped with a pin's head, or only so slightly scratched with its point as to be inaudible to the performer, is the percussion or scratch distinctly heard by a person standing at the other extremity of the log or beam?—BECAUSE, as the

particles of wood are in perfect continuity, and exactly contiguous to each other in the lengthwise direction of the wood, the percussion is communicated to the air at the opposite extremity, but the particles of the wood in the breadthwise direction having no opposite continuity to those in the lengthwise direction, do not communicate the sound of the percussion at either extremity of the breadth.

WHY does water or a long piece of wood conduct sound better than air?—BECAUSE all bodies the particles of which vibrate (the property of material bodies) conduct sound in proportion to their density.

WHY does a cracked or flawed bell emit an imperfect sound?—BECAUSE the separation of the continuity of its various particles produced by the crack occasions the two separated parts to jar.

WHY, though we have two ears and two eyes, do we hear the same sound only once, and do not see the image of an object double?—BECAUSE the nerves which receive the impression of sound have a point of reunion in the brain; and the two nerves that receive the image in each eye are united previous to their reaching the brain.

WHY, when the air is exhausted or drawn out of the receiver of an air-pump, will neither a bell sound, nor gunpowder explode, and will animal life be extinguished, and why is there no difference in weight between a piece of lead and a feather?—BECAUSE it is air that produces sound, feeds fire, supports life, and makes the distinction between weight and lightness.

WHY, if a piece of wet rag be put into a heated tube of iron, as into the barrel of a gun or cannon which has become hot by repeated discharges, is the rag expelled with force without any visible or sensible cause?—BECAUSE the water

which the rag contains, or is partially saturated with, is converted into steam, which puts the rag into motion and expels it from the gun or cannon.

WHY, when the air is cold and dense, is the hearing very acute, and when it is warm or sultry does the reverse happen? —BECAUSE during the continuance of a cold and dense state of the air all the muscles of the tympanum or drum of the ear are much contracted, and therefore a tension of the tympanic membrane being produced, the tympanum is easily acted on by sound; but during the existence of warm weather the reverse, that is, a relaxation, taking place in that membrane of the ear, the hearing is dull. Another cause also of this phenomenon is, that as the atmosphere is the medium for the conveyance of sound, the more it is condensed, as is the case in cold weather, the greater is its conducting power, and when warm or hot its conducting power is less on account of its rarefaction.

WHY is the sound of music deadened when an apartment is covered with carpeting or woollen cloth?—BECAUSE the air and the solid fibres in the carpet or woollen through which the sound has to pass deaden the echo between the ceiling and the floor, by which the original sound is swelled.

WHY do fish inclosed in a globe or jar of glass appear utterly insensible to any sound excited in the air outside the vessel (if unaccompanied with motion); but that the slightest tap with the nail of the hand on the edge of the vessel, although made in such a situation that the motion cannot be seen by the fish, immediately disturbs them?—BECAUSE the intensity of sound excited in any medium being proportioned to the energy of the original impulse, it is therefore much greater when arising from the direct impact of a solid body on water or its con-

taining vessel than from that of the particles of the air in a sonorous wave whose momentum is necessarily very small.

WHAT occasions the explosive sound produced by the ignition of gunpowder and other combustible materials?—THE sudden and rapid disengagement of the air confined in the gunpowder or combustible; and its shock of striking upon the volume of the external atmosphere.

How was the colossal statue of Memnon, in Upper Egypt, enabled to emit musical sounds at sunrise?—BY a current of air, rarefied by the rising sun, impinging against the spangles of the crevices of the sonorous granite of which the statue is composed. Analogous phenomena occur in granite rocks in other parts of Egypt, and on the banks of the Oroonoko, in South America.

WHY do two clocks or watches set agoing on the same shelf, or which have been affixed to the same wall, possess similar sympathetic vibrations, namely, that the pendulum of the one will stop that of the other, and that the pendulum of the stationary one will, after a time, resume its vibrations and stop those of the other clock?—BECAUSE of the communication or sympathy of the vibrations through the medium of the shelf or wall.

WHY is a tumbler broken to pieces by the singing close to it of a person who has a clear and powerful voice?—BECAUSE of the vibration of the voice being sympathetically communicated to the glass; the vibrations produced act upon the glass in the same manner as the fingers of the player on the keys of a musical instrument.

WHY, when a gun is fired at a distance over the smooth expanse of a frozen lake, are two reports heard after the flash; the first a sharp and loud one, and the second a weak and

duller one?—Because the first is transmitted by the solid ice, and the second through the air.

Why do massive stone walls, and even the ground itself, responsively vibrate and tremble at particular notes in music or the sound of a powerful voice?—Because of the sympathy that exists between the sounds produced and the elastic subtle matter or fluid contained in the wall, and which seems to be universally diffused throughout animate and inanimate nature.

HYDRODYNAMICS.

Hydrostatics and Hydraulics.

Hydrodynamics (from ὑδωρ, water, and δυναμις, power) is that branch of mechanical science which treats of the force and power of fluids, namely, their pressure, equilibrium, cohesion, and motion; and is subdivided into two parts, Hydrostatics and Hydraulics. Hydrostatics (compounded of two Greek words, signifying *water* and *to stand,)* treats of the weight, pressure, equilibrium, and cohesion of fluids in a state of rest, and the phenomena of capillary attraction; and Hydraulics (from two Greek words, signifying *water* and *a pipe,)* investigates the laws which regulate the motion of fluids, as also their resistance and percussion, together with the artificial means of conducting liquids in pipes, or raising them in pumps, and the constructing of all kinds of machines relating to them.

Hydrostatics and Hydraulics.

What is meant by water finding its level?—Its natural law or tendency to stand at the same surface level in all parts of its mass.

Why does water seek the lowest level for its repose?—Because of the force of gravity.

Why does water run or flow?—This is a problem that is not in our present state of knowledge philosophically solvable; for the fluidity of water depends on the attraction of gravitation, which is one of the unveilable mysteries of Nature.

Why do fluids accommodate themselves to the shape of the vessels containing them, and take their form?—Because fluids want cohesion among their parts, and on that account are incapable of assuming form without external support.

Why is the resistance of fluids less than that of solids?—Because their particles acting separately or gravitating independently of one another, their cohesive attraction is less than that of solids, the parts of which are possessed of so firm a cohesion as to resist impression, unless a force be applied proportionate to their hardness and cohesive power.

Why do solid discs, as oyster shells, flat stones, &c. when made to strike the surface of the water at a small angle, rebound from the water, or make, as boys term it, "ducks and drakes?—Because of the elasticity of the water.

What occasions the uniform levelness of the surface of water?—The peculiar adaptation of the atoms of which it is composed to accommodate themselves to the shape and construction of vessels.

Why do some bodies float and others sink in water, or other fluid; that is, why do heavy bodies sink and light bodies swim?—Because their specific gravity or relative weight is

less or greater than that of water; that is, according as the weight of a body is greater or less than that of the bulk of water which it displaces, it will sink or swim; or in other words, heavy bodies have fewer atoms, and light bodies more atoms in equal bulks than water has; consequently a body heavier than an equal bulk of fluid will sink in that fluid, while a body lighter than an equal bulk of a fluid will swim on its surface; but if the body and the fluid are of an equal weight or gravity, the body will neither swim nor sink, but will remain suspended in the fluid.

WHY does the heaviest side of a floating solid body sink lower than the lightest side?—BECAUSE that it may balance itself on its centre of gravity, and adapt itself to the centre of the buoyancy of the water.

WHY does wood when thrown into water swim for some time and then sink?—IT swims at first because it contains air in its cells, and is thus lighter than water; but it sinks in time because the air becomes expelled by the pressure of the water, when the substance of the wood becoming saturated with water by the pressure of the superincumbent mass of water, its specific gravity being greatly increased, it becomes heavier than the quantity of water it displaces, and sinks. The expulsion of the air from the cells of wood is sometimes produced very speedily. A remarkable instance of this fact is related by Captain Scoresby in his account of his voyages to the Whale Fishery in the Arctic Regions:—a whale, on being harpooned, ran out all the line in the boat, and as the end of the rope was made fast, the boat was dragged by the fish under water, to the depth, it is supposed, of several thousand feet, the men having just had time to make their escape by leaping on a piece of ice. When the whale returned to the surface to

breathe, it was killed; but instead of floating, it began to sink as soon as it was dead, in consequence of the weight of the boat which was still attached by the line of the first harpoon remaining in its flesh. The sunken boat was raised with great difficulty; for it was so heavy, that, although before the accident it would have been buoyant when full of water, it now required a boat at each end to keep it from sinking. When it was raised into the ship, the oaken planks were, to use Captain Scoresby's words, "as completely soaked in every pore as if they had lain at the bottom of the sea since the flood." A piece of light fir wood, about fifteen inches square, that had gone down with the boat, when thrown into the water again, sank like a stone.

WHY are some fluids capable of supporting bodies of greater weight than other fluids are?—BECAUSE of their greater density or specific gravity. Thus, sea-water will support a greater weight than fresh water will, being saturated and rendered denser by foreign matters, namely, the mineral or saline particles which it contains, a cubic foot of sea water weighing in general about seventy-three pounds, while a cubic foot of fresh water weighs only seventy pounds.* It is for this cause, namely, the difference in the specific gravity, that heavily laden vessels, which have sailed in safety across the trackless ocean, sometimes sink on entering the mouth of a river, sea water having generally a density of 35 parts in every 1000 more than fresh water has, and ships in dense salt water draw one 38th less than in fresh river water. It is for the same reason, that it is easier to swim in salt than in fresh water, be-

* The specific gravity, that is, the relative gravity or weight of sea water to fresh water, is 1.027.

cause salt water is denser and more buoyant than fresh water. Therefore, supposing the weight of a man to be one hundred and fifty pounds, if in fresh water his bulk displaces two cubic feet of water, he consequently has to sustain ten pounds of his weight by his own exertions, one hundred and forty pounds being supported by the water; but in salt water he will have to support only four pounds of his weight, one hundred and forty-six pounds being supported by the water. Thus a fat man swims more easily than a lean one, because the adipose membrane or fat of animals is not so dense as flesh or lean, and consequently it is of inferior specific gravity or lighter. It was from this cause that the Neapolitan priest, Paulo Moccia, was enabled to display his extraordinary facility of flotation, his body being thirty pounds lighter than an equal bulk of sea water.

WHY is a small quantity of water descending in a long column equal in pressure and effect to a large volume of water in a short column?—BECAUSE the law of pressure of water, and generally of all fluids, liquid and gaseous, is not in proportion to the volume of the horizontal surface (that is, the width or expanse), but according to the height of its column, and the area of its base; or in more abstract language, the pressure is all in one point, and none of it is expended laterally. It is in consequence of this fundamental law of hydrostatics, that the dams and embankments that have been raised to protect Holland from the encroachments of the sea, are not carried away by the force and pressure of its waters, which assume strength and density in proportion to their depth. By the same law, the earth is enabled to resist the immense weight or intensity of pressure of the ocean from crushing it to pieces. It is also in obedience to this primary principle of hydro-

statical science, that the embankments of dams and canals are made to slope gradually from the summit to the base, in order that greater strength may be given to the base; and it is for the same reason, that the lower hoops of large vats are made of greater strength than the upper ones, namely, to prevent their bursting.

WHY does the water running from orifices of equal diameters in two vessels of different altitudes, flow in unequal quantities in the same period of time?—BECAUSE the hydrostatic pressure on the vertical height of the water is equal to the velocity that a body would acquire in falling through a space equal to that height. It is for this reason also that the velocity of water rushing out from three or more stop-cocks in the sides of a vessel, varies in proportion as the cocks are higher or lower in the sides, because the velocity of the respective streams is in the exact proportion to the respective distances of the points of discharge from the superior surface, and the consequent pressure downwards from the surface to the respective orifices.

WHY do a pipe or tube projected into the interior of a cask or other vessel, and a hole simply bored into the cask, discharge different quantities of water, though the height of the liquid contents, or the pressure of the perpendicular column of liquid particles, is the same; in briefer language, why is the diameter of a stream of water, discharged from a cock or tube, less than that discharged from a hole or aperture of the same diameter?—BECAUSE the columns of liquid particles which descend from near the internal parietes of the vessel, by turning up again in consequence of the opposition with which they meet from the projecting of the tube or cock, come into more direct opposition to the motion of the central descending columns than they would have done had there been

only a simple hole or aperture, while they are themselves compelled to turn suddenly in opposition to their own inertia, before they can enter the cock or tube.

WHY is water issuing from three apertures made in the side of a vessel at different heights, projected with different impetuosities corresponding to their depths from the top of the vessel?—BECAUSE the apertures are affected according to the intensity of the pressure of the liquid at their respective heights, and that the width of curve produced by the discharge of liquids from apertures is partly affected by the width of the aperture, and the consequent friction and cross currents.

WHY are persons going or falling into water if they float upon their backs not drowned though they cannot swim?—BECAUSE the human body in a state of health, with the lungs full of air, is specifically lighter than water; therefore if a person so circumstanced stretches himself upon his back, and lies with his face above the water, with the bulk of half the head above the surface, he may live and breathe until chilled or otherwise paralysed.

WHY does water flow with most advantage from an orifice in the form of a short round tube inserted into the vessel, and of a length equal to twice its diameter? And why does water flow with the least possible retardation from a trumpet-mouthed or funnel-shaped tube?—BECAUSE in each case, the friction of the particles of the water against the parietes of the tube is diminished, and consequently the flow of the liquid promoted.

WHY does a smooth leaden pipe convey more water than a wooden pipe of the same bore or diameter?—BECAUSE the water is less retarded by friction and inequalities in the leaden pipe than in the wooden one. For the same reason a straight pipe conveys more water than a pipe which has a bend or angle in its course.

WHY will a pipe of twice the capacity of another pipe transmit five times the quantity of water that the smaller pipe will? — BECAUSE the water sustains less retardation from friction.

WHY does a stream of water issuing from a simple hole bored in a cask run in a screw-like form?—BECAUSE the cross or opposing currents created by the rush from the top and sides of the casks towards the orifice, impede, by their inertia, the descent or downward progress of the vertical or perpendicular columns of the water, and thus cause them to flow in a screw-like form.

WHY does an orifice at the bottom of a reservoir or containing vessel allow a larger and quicker discharge than one made at a higher position?—BECAUSE the quantity of water discharged conjointly with its degree of velocity produced by the pressure of the liquid in all directions is increased in proportion to the pressure of the vertical column of the water.

*** Between the descent of water in its discharge, and that of bodies from a height, there subsists a great coincidence or relation. For though the descent of water is not as the ratio of its vertical height, yet if the height is quadrupled, the velocity will be doubled; if the depth is increased ninefold, the velocity will be threefold; for a fourfold velocity, a sixteen-fold depth is required, and so on.

WHY are living bodies floating on water in a continual state of oscillation, alternately rising and sinking?—BECAUSE their magnitude and weight are subject to continual variation, being alternately increased and diminished by the action of breathing at each respiration and expiration. Thus, when the lungs are inflated by drawing in the breath, the volume of the chest, being slightly increased by the respired air, is rendered some-

what lighter than its own bulk of water; but when the lungs collapse by the expiration of the breath, the chest being diminished becomes heavier than its bulk of water, and consequently sinks.

WHY does raising or stretching the hands out of water endanger the safety of a person while floating on the surface of the water?—BECAUSE it diminishes the bulk of the body, and consequently renders it heavier than the quantity of the water that it displaces.

WHY does the human or animal body when first drowned sink, and after a certain time rise to the surface of the water and then sink again?—BECAUSE when first drowned, the air being expelled from the lungs, the body is heavier, bulk for bulk, than water, and consequently sinks; but when the process of decomposition has produced an accumulation of gas, the body being swelled and increased in bulk displaces more water than is equal to its own weight, and consequently rises to the surface. But when the vessels containing the gases thus generated burst, the body again contracting its dimensions displaces a less quantity of water than its own weight, and therefore sinks.

WHY do life-preservers enable the upper part of the body to be buoyant above the surface of the water?—BECAUSE, being inflated by air, they displace, in conjunction with the body around which they are attached, a larger bulk of water than their own weight. By the same principle, sunken vessels are raised by attaching to their sides casks filled with air, and ships are enabled to pass over shallow passages by fixing to their sides large chests filled with water, and then pumping the water out of the chests. And it is by a similar process that a person is enabled to walk upon the surface of the water, namely,

by attaching inflated bladders to his feet, and a staff with an inflated bladder tied at the end of it to preserve his balance.

WHAT is the reason that life-boats and vessels constructed of double plates of metal, including between them a hollow space so secured as to exclude the water, cannot be sunk?—BECAUSE if the space is sufficiently large between the plates, it displaces more water than is equal to its own weight. It is on this principle that the ball-cock for regulating the supply of water conveyed by pipes into cisterns and water-butts, floats on the surface of the water in the cistern; that sunken vessels or other bodies are, as has just been stated, raised at high water from the bottoms of rivers by air-tight casks attached at the lowest ebb of the tide by ropes or chains to the vessel or body; and that that ingenious invention called the water camel, used in Holland, Russia, and at Venice, enables large and heavily laden ships to pass shoals or sand-banks. It is proposed to prevent ships foundering at sea by a process somewhat similar; namely, carrying metal tubes, closed at both ends so as to exclude water, through various parts in the bulk of the ship, and in sufficient number to bear a proportion to the weight of the ship and the cargo.

WHY can quadrupeds swim more easily than men?—BECAUSE the natural motion of their legs in walking and running fits them better for the act of swimming.

WHY are fishes enabled to swim?—BECAUSE of the change of their specific gravity. When the air-bag with which nature has provided them is distended, they rise to the surface, and when they contract it, they descend to the bottom of the water.

WHY does a vessel that is water-logged (that is, filled with water by a leak or otherwise) float?—BECAUSE the specific

gravity of the material of which the vessel is composed is lighter than its own bulk of water which it displaces.

WHY are large and heavy bodies (as large and ponderous masses of stone) carried much more easily down rivers by the force of the water, than they can be moved on land?—BECAUSE, by the laws of hydrostatics, a solid body immersed in water weighs so much less than it does in air, by a sum equal to the weight of the mass of water which it displaces. It is by the same law also,—namely, that the attraction of gravitation, which is the cause of weight, is counteracted more in water than it is in air, (a consequence produced by the tendency of water to buoy up or afford a support to the object immersed in it, to the extent of the weight of the bulk of the water displaced by the object),—that a stone or other object, which cannot be lifted without considerable difficulty upon land, can be moved with comparative ease in water. And it is in conformity to the same principle of hydrostatics, namely, the loss of weight in solid bodies in proportion to the weight of the bulk of liquid that they displace, that the alloy and intrinsic value of gold and other precious metals are ascertained.

WHY is water enabled to transport large blocks of rock and other weighty substances with comparative ease to what air can?—THOUGH the power of both water and air is great when put into motion, the reason of the motive power of one exceeding that of the other is, besides that of the cause stated in the preceding problem, that much of the weight of the bodies is lost in the water on account of its greater density than that of air, and that the momentum or force of motive power is increased when descending an inclined plane, as water does, than when proceeding on a level, as air does.

WHY, if a bottle filled with fresh water is firmly corked and

sealed, and sunk to a great depth in the ocean, is the cork either forced in, or the bottle broken?—By the pressure of the water. If the cork has not been forced in, it has been so squeezed by the pressure, that it allows the salt water to ooze in and out by it, when the water in the bottle will be saltish. The reason that the cork, on the bottle rising, is found in its place is, that it has resumed its original size in the course of the bottle's ascent, from the diminished pressure of the superincumbent water.

Why cannot divers descend in the sea beyond a limited depth?—Because of the increased pressure which they experience in their descent from the superincumbent mass of water; the compressing force being at length so great as to expel the air from the cavities of the chest, and to contract the body so as to extinguish life. For these reasons divers cannot descend in diving-bells beyond ten or twelve fathoms.

Why do divers observe the air-bell to expand as it approaches the surface?—Because the pressure of the water is diminished by the ascent.

Why cannot the sea be sounded beyond a certain depth?—Because the specific gravity of the water increases according to its depth, and therefore the sounding line, when it reaches a point at which the specific gravity of the water is equal to its own, is suspended or held in equilibrium.

Why does water in the act of boiling sometimes flow out of the spout or force off the lid of the kettle?—Because the air inclosed in the space between the surface of the water and the lid having become expanded by the steam, acquires an increased elastic force, and overcoming the pressure of the atmosphere acting on the water in the spout, the water either flows out of the spout, or the pressure of the steam forces off the lid. These

consequences might be prevented by a small hole being made in the lid of the kettle, or by the lid not being made so tight as to exclude the communication between the external air and the interior of the kettle.

WHY does the liquid in a teapot sometimes cease to flow, or why does it flow very slowly after a small quantity of the contents of the pot have run out?—BECAUSE the lid fits too close, or is air-tight, or that some of the liquid which lies round the edge of the mouth of the pot stops all communication between the surface of the liquid in the vessel and the external air, whereby the air under the lid becoming rarefied, and the pressure on the surface of the liquid in the tea-pot being consequently diminished, the atmospheric pressure resists its discharge at the spout. To prevent this effect is the reason that a small hole is made in the lids of tea-pots.

WHY does water, if poured from a jug which has not a spout or projecting lip, run down the side of the vessel instead of falling perpendicularly?—BECAUSE the water is operated on by adhesive attraction. For the same reason a plate of glass when brought into contact with a level surface of water adheres to it with considerable tenacity and resists a separation; pieces of wood floating in the water attract each other, and remain in contact; and by the same property the wrecks of vessels are found gathered and adhering together in heaps when the sea is calm.

WHY, when an inverted tumbler is plunged into water, does no water enter it?—BECAUSE the air contained in the tumbler resists the entrance of the water.

WHY does not the water run out of a tumbler filled with water and a piece of paper put upon its top, when the tumbler is turned upside down and held perpendicularly?—BECAUSE

the hydraulic or hydrostatic pressure occasioned by the volume of water contained in the glass is resisted, and the water prevented from running by the resistance of the air under the paper.

WHY, if a piece of paper is laid on the surface of water in a vessel, and wine or spirits are gently poured upon the paper, will the wine or spirit continue to swim on the top of the water, on the paper being carefully removed so as not to disturb the liquids?—BECAUSE wine and spirits are lighter than water.

WHY does a bottle filled with water, and dipped with its neck downwards into a jar or barrel of spirits, become emptied of the water and filled with the spirits?—BECAUSE the water being of greater density than the spirits falls downwards, and the spirits being specifically lighter, by the laws of hydrostatics supply its place.

WHY is a bottle, when pushed into water with the mouth downwards, not filled with water?—BECAUSE of the resistance of the air and the goblet to the water.

WHY, if a floating lighted taper be placed in an inverted tumbler pushed into water, will the taper continue to burn when the tumbler is below the water?—BECAUSE the air contained in the tumbler supports the combustion, and the taper will continue burning under the water, while the original principle of the air is not exhausted. It is on this principle that the diver supports life in the diving-bell, which is emblematic of the taper and tumbler.

WHY, if a few drops of water are gently poured into a vessel containing wine, do they not mix with the wine, but float on the surface?—BECAUSE the momentum of the particles of the water poured into the vessel is not increased so as to give them velocity.

WHY is cream formed on the surface of milk?—BECAUSE

being composed of the lightest particles of the milk, it gradually rises through it and settles on its surface.

WHY does the sucker of a pump draw the water up from the well?—BECAUSE when the piston is drawn up a vacuum is made in the hollow cylinder or pipe containing the piston, the air within the cylinder being exhausted by means of the action of the piston and valves; and as it is one of the laws of Nature that there cannot be a vacuum or empty space, a column of the water in the well is driven or rises up the tube or cylinder of the pump, the pressure of the air being removed from the surface of the water contained within the cylinder. On the same principle water rises in a squirt or syringe when the piston or handle is drawn up.

WHY cannot water be raised higher than thirty-two feet by means of pumps?—BECAUSE the water rises in the tube or cylinder of the pump only by means of the pressure of the air by the stroke of the piston, and as air will not excite water to rise above the height of thirty-two feet, (a column of air extending the whole height of the atmosphere, and one of water of the same diameter, being of exactly equal weight,) the water and air remain in equilibrio. When water, therefore, is required to be raised higher than thirty-two feet, it must be either by means of a forcing pump put into action either by animal power or by the force of machinery, or it must be conveyed into a reservoir, when it may be raised another thirty-two feet, and so successively; or advantage must be taken of the natural law of fluids, namely, their disposition to find their equilibrium or exact level. This is done by first conveying water to an elevation by means of forcing machinery, when it will, through the medium of tubes or pipes, rise to an elevation equal to that of the place from which it flows.

WHY does water rise in a fountain or jet-d'eau?—BECAUSE they are formed below the level of the water from which they are supplied. This is accomplished by first raising the water to a considerable elevation; it is then carried by pipes to a lower level than its original height, when being permitted to escape, it rises with a force proportioned to the height of the source from which the water is supplied. By the same means, (namely, by selecting a reservoir in a situation more elevated than the place to which the water is to be supplied, and feeding such reservoir from natural sources or by mechanical power) water is made to rise to the tops of the highest houses in towns or cities from rivers many hundred feet below the level of the places supplied; the pipes being often carried up and down the steepest hills in their course, as is the case in the city of Edinburgh.

WHY do air-bubbles in a glass of water gradually dilate as they ascend from the bottom of the glass to the surface of the water?—BECAUSE the pressure of the water upon them becomes less and less in the proportion of their ascent.

How are intermittent springs, such as the Wedding Well in Derbyshire, &c. produced?—BY the pressure of the air upon water collected in cavities in mountains, rocks, or hard soils, and carried off by natural syphons or passages when full. The intervals of the periodical flowings and cessations of such springs depend on the quantity of the water furnished.

WHY does water melt sugar, salt, &c. and incorporate them with itself?—BECAUSE it reduces them to so fine a state as to disunite their component particles.

WHY does water or other liquid brimfull in a vessel not overflow or appear to increase in quantity, although a certain portion of sugar or salt has been dissolved in it, or that spirits of wine have been poured into it?—BECAUSE the particles of

the sugar or salt, or the spirits of wine, by expelling the air which was in the water, and introducing themselves between the pores and interstices of the water, merely occupy the space that was taken up by the expelled air. When more than can find room between the pores and interstices has been poured in, then the liquid will overflow.

WHY does the liquid in a vessel appear raised a little at the sides or border of the vessel?—BECAUSE it is attracted by the solid with which it is in contact.

WHY does liquid when in an immense mass, and presenting a large surface, have the appearance of a curved sphere in its middle?—BECAUSE the collective gravitation of all its particles towards the centre of the earth causes it to partake of the general figure of the terrestrial globe.

WHY does pouring oil on the surface of the sea in a storm calm the foaming waves and allay the mountain billows?—BECAUSE the inferior specific gravity of the oil forms a floating film which defends the surface of the water from contact with the currents of the air, and thereby the friction between the wind and the waves is greatly diminished, in the same manner as the friction between solids is diminished by the application of unctuous matter.

WHY does oil float on the top of water, even when water has been poured over it?—BECAUSE oil is lighter than water.

WHY do oil and water combine or form one mass when a few drops of strong ammonia, or a little soda or potass, are added to them?—BECAUSE their discordant parts are chemically attached by those substances.

WHAT occasions bits of camphor and of some other substances to appear agitated when placed on water?—THE resistance opposed by the air and water to the jets of essential oil

thrown out by such bodies. The same motion may be produced in any substances so placed, if artificially impregnated with essential oil. It is thus that the artificial gyrations of the wick of the hydrostatical lamp are occasioned.

WHY does the blood stop running after a certain time when a finger or any other member of the animal body is cut or wounded?—BECAUSE the blood which settles on it, by cooling down below its natural heat of 98°, plugs up the wound, and gradually becomes firmer and firmer till it assumes the texture of flesh. The rapidity or delay of the thickening depends on the size and strength of animals. Thus it takes from two to fifteen minutes in the horse, while it requires only one-sixtieth of a minute in the mouse.

WHY, if mercury, sea-water, fresh water, oil, and spirits be gently poured into a glass vessel, will they preserve their positions in the vessel, according to the order in which they have been poured in; and why, if mercury, oil, and spirits be shaken together in a phial, so as to form an apparent homogeneous mass, will they separate and remain distinct from one another? —BECAUSE they retain their position according to their specific gravities; the arrangement depending on the relative weights or densities, the heaviest gravitating to the bottom of the vessel, and the others floating at heights corresponding to their weights. The reason is the same that they resume their places when they have been intermingled by shaking them together. The same phenomenon would take place, and for the same reason, in whatever order the ingredients had been introduced into the vessel. Thus, had fresh water been first introduced, and then sea water been poured upon it so gently as not to disturb its pressure, yet the sea water would soon sink below the fresh water, and the fresh water ascend.

WHY, if water, oil, and mercury are shaken together in a phial, will they, after being allowed to settle, separate, and remain distinct from one another?—BECAUSE they are of different densities, and therefore the oil being the lightest, and the mercury the heaviest, the one floats at top and the other sinks to the bottom, while the water being of an intermediate weight remains in the middle. Had spirit been added to the mixture, it being lighter than oil, would have floated above it.

WHY, if the end of a towel be left in a basin of water, will the basin be emptied of its contents?—BECAUSE of its capillarity, or in consequence of capillary attraction. It is for the same reason that sponge imbibes water, blotting-paper absorbs ink, oil rises amidst the fibres of the cotton-wick of a lamp, and that aqueous fluid ascends and spreads through a lump of sugar or any other porous substance.

WHY, if one end of a slip of woollen cloth, having been soaked in wine, be put into a vessel containing a mixture of wine and water, and its other end be placed in another vessel which is empty, will the wine detach itself from the water, and go into the empty vessel?—BECAUSE, as wine has more affinity with wine than it has with water, that is, unites better with it, the vinous particles in the water are attracted to those in the slip of woollen cloth, which when fully saturated distils its superabundant moisture into the empty vessel.

WHY are brittle vessels, such as earthen water-pipes, bottles, &c., in which water has frozen, burst while the frost continues, but leaden vessels not until a thaw takes place?—BECAUSE the bursting of the brittle vessels is occasioned by the expansion of the particles of the fluid, which when they crystallize or assume the solid state, unite by certain sides in preference to others, and arrange themselves so as to form deter-

minate right angles, an arrangement requiring more space and forming numerous vacuities, and consequently enlarging the bulk; but the disruption of leaden pipes, which are possessed of considerable tenacity, is produced by the water being forced out with a velocity corresponding to the vertical height of the column of water in the pipe. From a similar cause, also, portions of steep banks often fall down after a thaw; for the moisture which was in them having expanded by the thaw, disintegrates their parts, and rends them to pieces. On the same principle, footpaths and gravel-walks become soft on the approach of a thaw.

How is the rending of mountains, or those crevices which reach from their summits to the internal reservoir of water which is near their base, produced?—By the intense lateral pressure occasioned by the vertical height of the column of water that has perforated them, in addition to the expansion of the liquid occasioned by freezing during winter. By the same cause, the bursting of walls behind which earth has been piled, and where no provision has been made for the outlet of water; as also the bursting upwards of drains running on a declivity, when they become checked, happens. It is from the same cause, that a cask or hogshead filled with water is burst by the pressure of a column of water contained in a narrow vertical tube fixed in the cask or hogshead.

Why should dams, ponds, canals, and vessels for liquids be made as shallow as is consistent with convenience or their required purpose?—To prevent their disruption or bursting.

Why are the lines of roads and canals so constructed as to partake of the natural or dead level, and not of the true or apparent level?—Because if they did not participate in the earth's sphericity, they would proceed in their course at a tan-

gent from the earth's convexity, and consequently reach to a point above that to which they were designed to go. Were canals not so constructed, the water could not be brought into their channels, and if it could, it would not remain there, but would rush towards the lower end.

WHAT is the use of locks on canals?—To enable the water to keep a proper level, on account of the irregularity of the surface of the country through which canals are constructed; for this purpose, therefore, at every change of level a lock is constructed.

WHY do ships float in a canal of no greater depth of water than is sufficient to keep the keel from touching the bottom?—BECAUSE the buoyancy and navigation of vessels are dependent on the vertical height of the water or its depth from the surface, and not on its width or expanse.

WHAT is the use of ballast in the bottom of the holds of ships?—To ensure them from being upset, by preventing their centre of gravity being elevated above their centre of buoyancy.

WHY can a tumbler filled with water be whirled rapidly round with its mouth inverted, and none of the water be spilled? Or why does water remain in a glass which is placed in a sling, and whirled round in the form of a circle?——BECAUSE the water is retained in the glass by the centrifugal force; or the water by its inertia of straightness or centrifugal force has a greater tendency from the centre of motion towards the bottom of the glass than towards the earth by gravity or the converging principle. By the same power, a stone whirled round in a string does not drop from the string.

WHY if a jug of water be placed on the inside of the rim of a wheel a few feet in diameter, and the wheel be put into rapid

motion, does the jug retain its place, and is the water not spilled; but if the jug is placed near the centre of motion, is the jug thrown to the ground and the water scattered about?—BECAUSE, in the first case, the centrifugal force by the rapid whirling of the wheel overcomes the force of gravity or the tendency of the jug to fall; and in the second case, the force of gravity of the jug exceeds the centrifugal force of the wheel.

CHEMISTRY.

CHEMISTRY, derived from an Arabic word signifying the knowledge of the composition of bodies, is that department of science which recognises and determines the nature, composition, properties, proportions of bodies, natural or artificial, and discovers the general and subordinate laws of their combinations and elementary changes in form and substance which they undergo by the processes of Nature and those of Art. In convertible and synonymous language, it is that science that enables us to ascertain the constituents of bodies, and the laws that regulate the combinations of the elementary particles or molecules of matter, which, as has before been said in a preceding page (135), are very few—the affinity and reciprocal action of bodies on one another proving that all bodies, whether large or small, whether the ponderous globes of the universe, or the most infinitesimal particle of dust or sand, or the smallest globule of water, are constituted merely in Nature's laboratory by the change of the arrangement of the same elementary ingredients, the disposition of the same materials into other

forms without the loss or destruction of the most inconceivably small particle of the original constituents. This grand and primary truth, declarative of the incomprehensible and omnipotent power of the Deity, is admirably illustrated by the processes of Art. The particles of burnt charcoal, wax, or any other substance, tangible or not, have by their combination with the air become again what they were before they were converted into charcoal, wax, &c. and their original constituent molecules are susceptible of running again and again the same round of recomposition and decomposition and becoming the elementary constituents of animal, vegetable, or mineral matter, consigning once more the animal matter to its kindred and parent dust, and the vegetable and mineral matter to a long repose in the rocks and bowels of the earth, till the lapse of time, the concurrence of circumstances, and the revolutions and vicissitudes of Nature, again impart to them vitality, so as to enable them to acquire their former activity and usefulness in Nature's grand and comprehensive plan. Many other similar illustrations might be suggested; but space limits the illustration to the relation of a single instance of the effect of chemical action. A solution of the salt called *nitrate of silver*, and the hyposulphate of soda, has each of them separately, when taken into the mouth, a disgustingly bitter taste; but if they are mixed, or the one is tasted before the mouth is thoroughly cleared of the flavour of the other, the sensible impression is that of intense sweetness.

WHY is cooking of use to food?—BECAUSE it renders the food palatable and nutritious, and in some cases destroys the deleterious property of vegetables.

WHY are provisions cooked or dressed by boiling?—BE-

CAUSE they are penetrated by the steam or heat of the water that surrounds them.

WHY are provisions cooked or dressed by roasting?—BECAUSE their fibrous structure is gassified or taken up by the penetration of the heat or caloric of the fire.

WHY does yeast occasion bread and malt or spirituous liquors to ferment?—BECAUSE when the yeast is placed in a warm situation, the carbonic acid gas contained in it endeavouring to escape, causes the bread to rise, and the liquors to ferment.

WHY do beer, ale, porter, &c. froth and effervesce, and champagne sparkle, when drawn or poured out?—BECAUSE the fixed air held in combination with the liquor being relieved from the pressure of the atmospheric air, which was condensed under the cork, &c. makes its escape, and rising in bubbles produces the froth, effervescence, or sparkling belonging to those liquors when good.

WHY are meat, fish, &c. preserved from being tainted by laying pieces of charcoal around them and upon them?—BECAUSE the charcoal absorbs the gases of incipient putrefaction and condenses them in its pores.

WHY does drying or smoking preserve meat, fish, &c.?—BECAUSE the natural juices of the meat, fish, &c. have been extracted, and thus fermentation prevented. Smoked provisions keep better than dried, because of the pyroligneous acid with which they have been impregnated from the smoke.

WHY does ink become black by exposure to air, though pale when first written?—BECAUSE of the action of the atmospheric air upon the copperas of its contents.

WHY do pearl-ash, pipe-clay, and fuller's earth remove grease spots?—BECAUSE the alumina which they contain having an

affinity for grease, they chemically unite with it, and form a species of soap.

WHY will not oil and water, violently agitated together, coalesce?—BECAUSE they have no affinity for each other. The addition of a little caustic ammonia will, however, cause their union, forming an ammoniacal soap.

WHY has snow-water a superior activity in causing iron to rust than rain or river water?—BECAUSE it contains more oxygen.

WHY does mortar cement?—BECAUSE of the affinity or chemical attraction between its constituents and those of brick, stone, &c.

WHY does some stone decay rapidly, although very hard when first dug from the quarry?—BECAUSE its composition consists of a large portion of clay or alumine, which absorbs the moisture of the atmosphere.

WHY does sugar occasion liquids and other substances to be sweet?—BECAUSE of the extreme divisibility and diffusion of its particles through the liquid or substance. The cause is the same that perfume and flowers diffuse their odour and fragrance; that various smells diffuse disagreeable exhalations; that colours tinge liquids and substances; and that the deliciousness, bitterness, or nauseousness of fruit, aloes, medicines, &c. affect the palate.

WHAT occasions bubbles to rise on a cup of tea when a lump of sugar has been thrown into it?—THE rise of air contained in the pores of the sugar, which is extricated from it as it is being dissolved by the liquid.

WHY do sugar, salt, and other substances when dissolved in liquids, occupy a less space than the sugar, salt, &c. and the liquid do separately?—BECAUSE the atoms or molecules of each substance have been partially received into the vacuities

between the atoms or molecules of the other. For the same reason, different metals, when fused together, occupy a less space than they do when separate. Tin and copper fused together occupy one-fifteenth less space than they do in a separate state.

How is crystallization produced?—ARTIFICIAL crystallization is exhibited in the simple process of making barley sugar; the string on which it is formed being the nucleus in solid bodies on which the process begins.

WHY do the figures of crystals vary their form?—BECAUSE the form is influenced by the acceleration of the evaporation; if the process is slowly conducted, the particles of the solution unite with great uniformity; if hurried, the crystals are irregular and confused.

WHY do the salts, called *freezing solutions*, convert water into ice?—BY the sudden liquefaction of the salts in the water.

WHY do some salts when exposed to the air effloresce or fall to powder?—BECAUSE they have lost their water of crystallization.

WHY do some salts deliquesce, that is, become moist or liquid, by exposure to the atmosphere?—BECAUSE they attract moisture from the atmosphere.

WHY do metals, as iron and steel, rust?—BECAUSE of the affinity which they have for oxygen, which combining with the iron disunites small particles of it, and thus occasions the appearance termed *rust*.

WHY are human and other animal bodies, tools, &c. when left in certain streams of water, petrified, that is, covered with stone, copper, &c.?—BECAUSE the water in which they are left is impregnated with stone, copper, &c. or holds those bodies in solution; and thus they are incrusted in the course of time with the particles held in solution by the water.

WHY are black hats and clothes turned to a rusty brown color by sea-air?—BECAUSE the muriatic acid of the sea-air by its incessant action converts the black oxyde of black colors into a rust or brown color, in the same manner as when any acid put upon black stuff or cloth turns it brown.

WHY does soap or potash cleanse linen, cloth, &c. better than water will by itself?—BECAUSE the oxygen in the water is the more increased by their agency.

WHY does soap curdle in hard water?—BECAUSE the sulphuric acid of the sulphate of lime to which the water is indebted for its hardness, combining with the soda of the soap, the lime and oil or tallow are freed or decomposed from their respective combinations, and float through the water in flakes or curdles. On this principle, solution of soap will determine the relative hardness of water, and for this purpose it is generally employed by the well-digger and borer.

WHY do wet mould, clay, &c. become hardened by exposure to the sun and air?—BECAUSE the water evaporates, and the particles of those materials unite by fixed air.

WHY do metal buttons become tarnished when wrapped up in white paper and laid by for a time; and knives and forks, and other steel and iron articles, when wrapped up in brown paper?—BECAUSE the white paper contains chlorine, or muriatic acid, which is employed in its being bleached; and the brown paper contains a quantity of gypsum or sulphate of lime, which is introduced for the purpose of increasing the weight of the paper.

WHAT is the cause that knives, razors, &c. made of silver steel do not rust?—BECAUSE the steel has been tempered with mercury.

WHAT occasions a silver spoon when immersed in an egg to

change its color?—BECAUSE the sulphuretted hydrogen of the egg has acted upon the metal.

WHY are brass cocks in leaden cisterns corroded at the junction of the brass of the cock and the lead of the cistern?—BECAUSE of the chemical effect of the contact of the metals. The same effect is produced on iron fixed in stone with lead. The same effect being also produced by the galvanic action of the iron nails used in fastening the sheets of copper to the bottoms of ships, copper nails have been substituted.

WHY is fermentation of use to wines, malt liquors, &c.?—BECAUSE it elaborates the decomposition of the saccharine matter or sweet principle of the wine and promotes its spirituosity.

WHY is excessive fermentation injurious to wines and malt liquors?—BECAUSE it occasions their decomposition.

WHY are wines and malt liquors improved by being sent to sea, or by the adventitious benefits of artificial heat, or the motion of the cask suspended in a sling?—BECAUSE the due amalgamation of the constituents of the wine is promoted, and its spirituous and aqueous particles exuded or evaporated.

Why are brandy, whisky, gin, rum, and similar liquids, more intoxicating than ale?—BECAUSE the alcohol present in them is more concentrated.

METEOROLOGY.

METEOROLOGY (from the Greek words μετεωρα and λογος) is that branch of physical science which explains the phenomena

of the air, the winds, clouds, rain, hail, snow, dew, thunder, lightning, and the luminous meteors; the diversified appearances of the sky, and the various changes or vicissitudes of temperature to which the weather is subject; with all the physical causes which affect the state of the atmosphere.

The Air.

Air, one of the great elements of nature, consists of four gases; two, oxygen and nitrogen or azote, originally inherent in the atmosphere; the other two, carbonic acid gas and water in a state of vapour, accidentally engendered in the same medium. Oxygen is the life-air of the animal creation, carbonic acid gas that of the vegetable.

Why is air of use?—Because it preserves and supports animal and vegetable life, conveys sound, nourishes combustion or fire, conducts heat, reflects light, and diffuses smells.

The Wind.

Wind is air put into motion, and is occasioned either by change of temperature or rarefaction by means of heat, or by its condensation by cold. The changes of the weather and storms and tempests are produced by the same cause.

Why is wind of use in the economy of nature?—Because it purifies the air, tempers and moderates heat, brings rain, dries up unnecessary moisture, and restores the balance occasioned by any unwonted atmospheric pressure, which has disturbed the equilibrium of the atmosphere. It is also of use in navigation.

Why is wind variable; that is, why does it not always blow with the same force?—Because the agitation of the air is increased according as the wind meets with obstacles in its course.

WHY is the south wind warm, the north cold, the east dry, and the west damp?—BECAUSE the south wind comes from the torrid zone, or countries where the sun is most vertical. The north wind is cold because it comes from the frigid zone and the polar regions. The east wind is dry because it comes from the continent of Asia, where there are but few rivers from which moisture may be collected. And the west wind is moist because it comes from the Atlantic Ocean, from which it imbibes a great quantity of moisture. The coldness of northern and easterly winds is particularly felt from the excessive dryness absorbing the moisture of the animal skin.

WHY, then, is the west wind free from rain?—BECAUSE the moisture that it has imbibed in its passage is partly dispersed and scattered before it has reached a region of the atmosphere sufficiently elevated to be condensed into drops of rain.

WHY does a larger quantity of rain fall on the western than on the eastern coast of England?—BECAUSE the westerly winds prevail longer than the easterly do, and are charged with a greater quantity of moisture.

WHY do hurricanes occur chiefly and with the greatest violence in tropical climates?—BECAUSE, in consequence of the great heat which prevails there, the rarefaction of the air and the condensation of the atmospheric vapour into rain-drops take place more suddenly and violently than they can do in the more temperate regions of the globe.

*** The West Indies, the Isle of France, Siam, and China are particularly subject to hurricanes.

WHY does wind quicken evaporation of moisture in the air or wet on the ground?—BECAUSE it removes air saturated with moisture, and substitutes dry air in its stead.

How are whirlwinds, storms, tempests, hurricanes, and

tornadoes produced?—WHIRLWINDS are produced by the influence of electricity, or by the meeting of contrary currents of air in the same points. Storms, tempests, and hurricanes are produced by the same causes, or they are occasioned by the upper currents of the air being prematurely diverted downwards before their relative velocity has been sufficiently reduced by friction, and has gradually mixed with the lower strata of the atmosphere. Tornadoes arise from two such masses encountering in mid air. In convertible and briefer language, storms, tempests, and hurricanes are progressive whirlwinds, constantly revolving in horizontal vortices in the same direction, the rotatory motion being backwards in the northern hemisphere, but forwards in the southern. The electrical state of the atmosphere indicates the approach of storms by its occasioning the emission of sounds from inverted drinking glasses, &c.

OF what use are whirlwinds, hurricanes, storms, tempests, &c., in the economy of nature?—To render and preserve the atmosphere pure and salubrious by freeing it from noxious vapours, and thus preventing maladies, contagion, and death. All the seeming imperfections of nature, its dreadful visitations and convulsions, are necessary for the due order and preservation of its economy.

THE CLOUDS.

THE CLOUDS consist of upmoving columns of air, absorbing in their ascent the aqueous vapour drawn up by the heat of the sun from the surface of the earth and the waters; which, when they have reached a region of the atmosphere of equal density to themselves, are suspended or continue to float there.

WHAT produces the variety of colors observable in the clouds?—IT is occasioned by the reflection of the rays of the

sun on the particles of vapour of which they consist, according to their density and position with respect to that body.

WHY does the sky appear of a blue color?—BECAUSE the vapours suspended in the air reflect the blue rays of the sun more abundantly than those of the other primary colors; or rather, the vapours absorb all rays except blue, which is the most refrangible.

WHY does the sky appear concave, that is, high overhead and as if touching the ground at a distance?—BECAUSE of the optical illusion of its appearing more enlightened over our heads than it does at the sensible horizon, or that imaginary circle which is the boundary of vision.

WHY are the clouds of use?—BECAUSE they refresh and fertilize the earth by means of rain, and by their intervention protect it from the scorching rays of the sun.

WHAT occasions the shifting appearance which clouds take on the tops of hill and mountain ranges?—THE constant ascension, and the change of the warmer strata of the clouds formed in the valleys and on the surface of the sea.

WHY do clouds accumulate about the tops of hills and mountains?—BECAUSE the temperature of the region of the air in their localities is lower than the air was at the region from which they travelled to the hill or mountain range.

WHY do clouds when rolling on the tops of hills seem to tumble over on the far side?—BECAUSE they fall into an atmosphere of a higher temperature, when their particles being diminished into the gaseous form are invisible.

WHY, when a cloud ascends a hill, is it precipitated in the form of a shower of rain?—BECAUSE it enters a cold region and is condensed.

Rain.

Rain is produced by the particles of aqueous vapour of which the clouds are composed coalescing or uniting together from the diminution of atmospheric pressure; when, if the temperature is above the freezing point, becoming too heavy to be supported in the air, they fall in drops upon the earth. Its immediate or concomitant cause is change in the state of the weather.

Why are not the earth's evaporation and the exhalation of the breath as perceptible in hot as in cold weather?—Because the suspended moisture seen in the form of mists and clouds in cold weather, and the puffs of the breath, are conducted away in an ethereal state by the warmth and freedom of the air.

Why is rain of use?—Because it makes the earth fruitful, tempers and purifies the air, and supplies sources for springs and rivers.

Why are drops of rain larger in summer than in winter?—Because the particles of vapour of which they consist, then ascending higher, of course unite with a greater number of vesicles of vapour, both in their ascent and descent.

Why does more rain fall in summer than in winter?—Because more vapour rises from the surface of the earth in winter than in summer, and consequently more rain falls in that season.

Why does rain fall seldomer in flat open countries than in mountainous regions?—Because the mountains, rising high in the atmosphere, act as attractors to the vapours in the air.

The Rainbow.

The rainbow is occasioned by the rays of the sun, when shining on the opposite drops of falling rain, being refracted

or bent from their straight course through the rain. Lunar rainbows are produced by the moon's rays being reflected and refracted from a falling cloud.

WHY are rainbows more or less vivid, and more or less perfect in their formation?—THEY are more or less vivid in the proportion that the sun shines more or less bright on the opposite rain; and they are more or less perfect in proportion that the rain from which the rays of the sun are reflected is more or less diffused.

WHY are two or more rainbows sometimes occasioned? BECAUSE the rays of light are doubly reflected at different angles from the eye.

WHY is the air cold after rain?—BECAUSE of the evaporation of the moisture from the earth.

WHY is there more rain from September to March than from March to September?—BECAUSE the temperature of the air from September to March constantly decreasing, its capacity for holding vapour decreases, and consequently the vapour is precipitated in rain.

WHY is the rainbow always less than a semicircle?—BECAUSE it is always under the horizon.

HAIL.

HAIL is produced by the congelation of the globules of rain while traversing in their descent a stratum of dry air, or by currents of cold air in the higher regions of the atmosphere suddenly intermixing with the warmer air in which the drops of the globules of rain were suspended.

WHY are hailstones of different sizes?—BECAUSE they receive a new opaque coating of liquid as they pass through every layer of clouds in their descent or passage to the earth.

WHAT occasions heat in warm weather?—THE excessive accumulation of electricity in the atmosphere.

SNOW.

SNOW is occasioned by particles of vapour floating in the atmosphere aggregating together and becoming crystallized or frozen by a cold current of air below the freezing point mixing with them, when they collapse into flakes of snow.

WHY is snow of use?—BECAUSE it preserves the temperature necessary for the support of the vitality of vegetable life, preventing or obstructing the radiation or escape of the heat of the earth while vegetation is in a state of torpidity.

WHY is snow white?—BECAUSE of the tenuity or smallness of the particles of vapour of which it is composed. Ice when pounded becomes equally white.

FROST AND ICE.

FROST is vapour congealed; and ice is formed by losing its caloric or principle of heat by the agency of cold.

WHAT occasions frost?—THE absorption by the atmosphere of the caloric of bodies.

WHY is frost of use?—BECAUSE it clears and purifies the air, destroys noxious insects, and fertilises the earth.

HOW is the thawing of ice occasioned?—THE ice is melted by the caloric conveyed by the wind from the southern regions. The ice of rivers is burst by the melting of snow occasioning the rivers to swell.

VAPOUR, FOGS, MISTS, DEW, AND HOAR FROST.

VAPOUR is a collection of the small particles of water drawn up by the heat of the sun into the air. FOGS and MISTS are

collections of vapour drawn up by the same luminary, but prevented, by their becoming condensed by cold, from rising high enough in the air to form clouds. DEW is produced from the insensible vapours and exhalations which arise from the earth after sunset, when the earth, condensing the vapour with which it is encompassed, forces it to fall back upon itself in the form of dew. HOAR FROST is occasioned by dews becoming frozen either by powerful radiation or depression of temperature.

How is dew produced?—BY the radiation of heat and the condensation of insensible vapours by cold.

WHY are dews and mists of use?—BECAUSE they refresh and invigorate the herbage of the earth, as well as the whole vegetable creation, when suffering exhaustion from drought and the summer heats.

WHY are dews deposited in the greatest quantity on fine, clear, calm nights, and that but little is produced when the sky is overcast and cloudy?—BECAUSE on clear and calm nights the surface of the earth freely emits or radiates the heat imparted to it during the day, which being dispersed through the atmosphere, without receiving any equivalent return to compensate for the loss, its temperature necessarily falls so as to condense the surrounding vapour; whereas, if the nights are cloudy, the clouds, acting like a concave mirror, reflect back the rays of the heat which radiate from the earth, and thus prevent the diminution of its temperature.

WHY does not the earth radiate or throw out rays of heat while the sun shines?—BECAUSE then the earth receives in general more heat than it radiates or gives off.

THUNDER AND LIGHTNING.

WHAT are thunder and lightning?—THE natural electrical result of certain conditions in the atmosphere.

Of what use are thunder and lightning?—They are the compensating provisions of Nature to restore the equilibrium in the elasticity of the atmosphere when it has been disturbed, and to carry the electric fluid from places where it is superfluous to other places where it is deficient. Lightning also consumes noxious vapours, promotes the circulation of the air, tempers the summer heats, and disperses contagion.

What occasions lightning?—The unequal distribution of the electric fluid through the aerial vapour, and its consequent accumulation in vast quantities in one mass of vapour or cloud, and its deficiency in another taking place by any sudden and powerful condensation or rarefaction of the air, the electrical fluid, endeavouring to regain its equilibrium, flashes from the surcharged cloud to the cloud that is undercharged, or to the earth itself.

What occasions thunder?—The undulation of the air, produced by the discharge of the electric fluid. It is more or less intense, and of longer or shorter duration, according to the quantity of air acted on and the distance of the place where the report is heard from the point of discharge.

Why are thunder and lightning frequent in summer?—Because of the increased electricity of the atmosphere by the heat.

Why does thunder make a rumbling noise?—Because its explosion is re-echoed by the air.

Why are thunder-claps the loudest and longest in continuance in hilly and mountainous countries?—Because the reverberation is promoted by the nature of such elevations.

Why is the flash of lightning seen before the report of thunder is heard?—Because the motion of light is much more rapid than that of sound.

Why are there sometimes flashes of lightning without any

report of thunder being heard?—BECAUSE they proceed from distant thunder-storms.

WHY does it happen that during violent storms of thunder and lightning men and cattle are killed, and considerable damage done?—BECAUSE when the inflammable matter of which the electric clouds consist is thin and light, it will rise to the upper part of the atmosphere, where it will flash without occasioning harm; but when it is dense it will lie near the surface of the earth, where, taking fire, it explodes with a force to so surprising a degree as to occasion a loss of life to objects within the medium of its immediate action, or to do other considerable damage.

WHY do conductors conduce to the safety of buildings?—BECAUSE they attract the electric fluid, or lightning, to them, and conducting it along their extent, at length dissipate its force upon the earth.

WHY are the fireside, or taking shelter under a tree or near metallic substances, unsafe places in a thunder-storm, but the middle of an apartment or being in bed comparative places of safety?—BECAUSE in the first place carbonaceous matter, as soot, and in the second trees and metals, act as conductors of the electric fluid; whereas in the third case the electric fluid takes its direction round the walls, and in the fourth case the blankets and feathers of the bed are non-conductors.

WHY are vitreous tubes occurring in elevated sandy deserts, called "lightning tubes?"—BECAUSE they are supposed to have been produced by lightning, which having melted the sand to a considerable depth, forms the tube. These tubes, which are commonly of a sinuous form, and are rough on the outside, with solid and smooth walls internally, bear a similarity to the marine water-spouts or columns occasionally seen at sea, and described at page 65 ante.

Meteors, Falling Stars, Auroræ Boreales and Auroræ Australes, Halos, Mock Suns and Mock Moons, and Aerolites or Meteoric Stones.

Meteors, whether consisting of fire-balls or falling or shooting stars, are supposed to be inflammable exhalations (or, as the late Sir Humphrey Davy was of opinion, small solid bodies) arising from the earth to the higher regions of the atmosphere, and become ignited or inflamed by an electric spark or by the casual ignition or combustion of the hydrogen or inflammable portion of the atmosphere, when they either throw out showers of fire on all sides or shoot forth in a blaze till the inflammable matter of which they are composed is consumed.

How are ignes fatui, or, as they are more familiarly termed, from the superstitious notions attached to their appearance, "Wills-o'-the-whisp" or "Jacks-with-a-lantern," produced?—From oleaginous matter, or inflammable air emitted from the putrefaction and decomposition of animal or vegetable substances in moist, boggy, or marshy grounds, or from bodies in churchyards and other places entering into a state of putrefaction, which passing into the atmosphere continues to float there till ignition takes place.

How are the northern and southern lights, or the auroræ boreales and australes, produced?—They are supposed by some to be generated by electric matter, but by others to be produced by the refraction and reflection of the solar light on the subtle vapour that floats in the higher regions of the air.

How are halos or mock suns and moons produced?—By the reflection of the image of the sun, or that of the moon, on the clouds from innumerable particles of ice floating in the

higher regions of the atmosphere, when it is not dense enough to reflect the rays of light passing from those bodies.

WHAT occasions the halo, or extensive luminous ring which sometimes includes the sun or moon in a circular area of nebulous matter?—IT is formed by the intervention of a cloud between the luminous body and the earth.

In conclusion, the author of "SCIENCE SIMPLIFIED" begs leave to add, that he has endeavoured to present his readers with the most philosophical solutions and the most rational explanations of the various problems contained in the preceding pages that our present limited and imperfect knowledge of the laws and processes of Nature admits; and in that endeavour he trusts that he has not only striven to conform to the injunction of the poet—

> "Philosophy that does not dream or stray,
> Walks arm in arm with Nature all the day;"

but has also steered clear of "the dotage and delirious dreams" of those who

> "Start up sagacious, cover'd with the dust
> Of dreaming study and pedantic rust,
> And prate and preach about what others prove,
> As if the world and they were hand in glove."

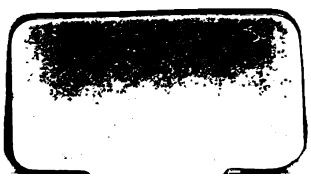
In making this declaration, however, he willingly and candidly admits that, in some cases of his solutions, hypothesis and speciousness of reasoning may have assumed the place of true science and veritable causes. The difficulties and imperfections under which scientific knowledge labours, and the utter impossibility, in our present imperfect state of intellectual excellence, of explaining the primary and physiological causes and principles of many of the operations of Nature, and

their *modus operandi*, are well elucidated by the author of "THE MEDICAL TOUCHSTONE"—a work calculated to convert the art of hygeiene from a chance-medley craft to a real and a rational science.

To that masterly exposition of physical facts and operations of Nature which are inscrutable and "past all finding out," the author of "SCIENCE SIMPLIFIED" adds that, though

> "The daring eye of Reason,
> Confusedly subdued to silence and amazement,
> In vain explores the fearful providence,"

it is consolatory and cheering to reflect, that what is ascertained by the evidence only of analogy may, in the course of time and the investigations of those master-minds that are employed in scrutinising the mighty wonders and mysteries of the Creative Spirit, and thus preparing the limited and imperfect capacity of man to assimilate to that of the Divine Nature, be confirmed by the evidence of the senses.

THE END.

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